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THE STRUCTURE OF THE ELECTRON [1]

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The general advances during the last twenty years in scientific knowledge concerning the properties of matter have been connected intimately with the unit of negative electricity, called the electron. Although the unitary nature of electricity was strongly suspected by Faraday, and others since his time, on the basis of electrochemical evidence, the conclusive demonstration of this is of comparatively recent date. The discovery [2] that cathode rays act as if they consist of negatively charged matter moving with about one-tenth the speed of light and show a nearly constant ratio of charge to mass, as would be expected of a stream of negative units, was soon followed by the development of methods [3] by which these particles have been caught in cloud drops of water and of oil. In this manner not only has the discrete nature of negative electricity been proved, but the elementary charge has been exactly measured [4] and found to be 4.774×10^{-10} of the customary electrostatic units.

[1] Rearranged from an address before the Freer Club, Manila. Received for publication April 15, 1921.

[2] Thompson, J. J., Phil. Mag. V 44 (1897) 298; Wiechert, E., Verhandl. der Physik.-Ökon. Gesellsch. zu Königsberg, i. Pr. (1897).

[3] Wilson, C. T. R., Proc. Roy. Soc. March 19, 1896; Phil. Trans. Roy. Soc. A 192 (1899) 403; Thompson, J. J., Phil. Mag. V 46 (1898) 528; Wilson, H. A., Phil. Mag. VI 5 (1903) 429; Millikan, R. A., Phil. Mag. VI 19 (1910) 209.

[4] Millikan, R. A., Science 45 (1917) 327.

THE MASS OF AN ELECTRON

According to the accepted electromagnetic theory any charged body has a certain mass (resistance to change of state of motion), which is due to nothing but the electric charge and depends upon its spacial distribution. The more concentrated a charge is, the greater is the mass due to it. For a given charge at a definite concentration the corresponding mass practically follows Newton's assumption of constant mass for any velocity up to and including those of cathode rays; that is, about one-tenth of the velocity of light. The idea that all the mass of ordinary matter is of this electromagnetic character was somewhat revolutionary when proposed by Larmor,[5] but the assumption of mass of any other kind, at least in the case of electrons, has been since shown to be entirely superfluous.

The mass of the electron has been found to be 9.01×10^{-28} grams [6] for all of the ordinary velocities at which it has been measured. According to experiments with the very rapid electrons given off by radium, which have been studied at velocities from three-tenths to eight-tenths of that of light, the apparent mass does not stay constant at this figure, but increases inversely with $\sqrt{c^2-v^2}$ (in which c is the velocity of light and v that of the electron [6]). Thus at one-tenth of the velocity of light the apparent mass of an electron is 9.1×10^{-28}; at three-tenths, 9.5×10^{-28}; at five-tenths, 10.4×10^{-28}; and at eight-tenths, 15.0×10^{-28} grams. As the experiments referred to measure the mass by forces transverse to the direction of motion, this is called the transverse mass. The longitudinal mass has been measured indirectly by optical experiments designed to show the absolute velocity of the earth through the ether. The explanation of the failure of such experiments to show any such absolute motion implies that the apparent longitudinal mass of an electron varies inversely with $(c^2-v^2)^{\frac{3}{2}}$.

ELECTRON MODELS WHICH HAVE BEEN PROPOSED

It would be logical to suppose that, since we find actual negative charges to be made up of units, we could consider these units, that is, electrons, not as "charged bodies," but as indivisible elements of negative charge. In the sense that the total

[5] Larmor, Phil. Trans. Roy. Soc. 186 (1895) 697.

[6] Bucherer, A., Ann. d. Phys. 28 (1908) 513; 29 (1909) 1063; Wolz, R., Ann. d. Phys. 30 (1909) 273; Schaefer, C., Phys. Zeit 14 (1913) 1117.

mass of an electron is electric, this is true. But mass is not a constant property of electric charge; it depends on the distribution of the charge. Therefore we must consider that an electron has a certain *distribution of charge within it.* Evidently the conception of negative charge must be applied to portions of the electron. It has been customary to assume that an electron at rest has spherical symmetry, and that the charge resides only on the surface, as it does on charged conductors of observable size. The mass of such an electron is accounted for by the accepted electromagnetic laws, if its radius is about 1.8×10^{-13} centimeters. The mass of a spherical electron would vary with its velocity, but not according to the law experimentally verified (see above). Lorentz [7] has shown that it is only necessary to modify the spherical electron by a contraction in the direction of the motion so that the dimensions in this direction become $\sqrt{1-\frac{v^2}{c^2}} : 1$ as compared to the dimensions of the electron at rest. This is certainly only a special case of a quite general principle, and may be looked upon as the consequence of the imperfections of our ideas of space [8] or, perhaps, of our measurements of mass, rather than an actual contraction of the electron.

The Lorentz elastic shell electron is a satisfactory model for electrons, such as the β-rays, which have been separated from positive charges, but not for the electrons in the nucleus or those which surround the nucleus of an atom. Such electrons either are not of the shape suggested by Lorentz, or do not follow the classical electromagnetic laws. The fact that there are strong magnetic fields in atoms cannot be explained by Lorentz electrons rotating in orbits, because there is no accompanying emission of light. Now a continuous circular current would give a magnetic field without radiation. On this basis Parson [9] has developed his theory of a "magneton," or ring electron, whose diameter is about 3×10^{-9} centimeters, and which rotates with about the velocity of light.

Compton [10] has found that the scattering of X-rays is much greater than could be explained by the Lorentz electron, and

[7] Lorentz, H. A., Konink. Akad. Wetensch. Amsterdam, Versl. 12 (1904) 986; Theory of Electrons, 217.

[8] Minkowski, H., Raum und Zeit, Phys. Zeit. 10 (1909) 104; cf. Cunningham, E., Relativity and the Electron Theory. London, Longmans, Green & Co. (1915).

[9] Parson, A. L., Smithsonian Misc. Coll. 65 (1915–16) No. 11.

[10] Compton, A. H., Phys. Rev. 14 (1919) 20, 247.

concludes that electrons in atoms are rings about 4×10^{-10} centimeters in diameter.

Although the conception of a ring electron obviously extends somewhat the applicability of the known electromagnetic laws to forces within atoms and molecules, no one has ever proposed a quantitative explanation of the characteristic behavior of an accelerated electron on this basis.

THE CHEMICAL PROBLEM OF TO-DAY

The ultimate and fundamental problem of chemistry is to express in some intelligible and quantitative manner the interaction of atoms at short distances. Since modern physical research tells us that atomic forces are only the aggregate of electronic forces, it seems that the problem may be simplified, and we need only find the manner in which electrons and positive electric units act at short distances, including the interaction of like and unlike units.

The laws of action of like and unlike charges at relatively long distances were the subject of much investigational work in the nineteenth century, and were shown by Maxwell [11] and others to be expressible in a few simple equations now known as the classical electromagnetic theory. This theory has been thoroughly verified for all distances between those of molecular dimensions and very large ones; but it is not a complete expression of the observed facts concerning electricity. To explain experimental evidence not provided for by the classical theory we have two alternatives:

1. To consider that the classical theory is valid even for infinitesimal distances but that there is some *additional influence* quite external to the facts covered by this theory.

2. To discard the classical theory and invent new laws which will explain the experimental evidence.

In the problem of atomic forces the most obvious fact not explained by the classical theory is the *existence* of the electron. The theory says that negative charge, unless bound or confined in some way, has a powerful expansive action due to the repulsion of every infinitesimal part of it for every other part. The fact is that we find finite particles of negative charge which show no tendency to expand. Adopting method 1 we

[11] Maxwell, J. C., Electricity and Magnetism, ed. 3. Oxford, Clarendon Press (1904); cf. also Hertz, H., Electric Waves. London, Macmillan and Co. (1900).

would say that the classical theory applies even within the electron, and that even infinitesimal subdivisions of an electron may be treated mathematically as charged elements. This view necessitates the additional assumption of a binding force or influence which keeps the charge within an electron from expanding indefinitely. In explaining the mass of an electron this method was long ago tentatively accepted, principally because a very simple assumption concerning the binding influence gives a Lorentz electron (see above) which explains exactly the observed mass of β-ray particles. Nevertheless many physicists seem to prefer to use method 2, and say that an electron is an indivisible unit whose mass is the same as it would be if it were constructed as suggested by method 1. This is probably because they prefer to think of an unchangeable unit of charge [12] rather than a mysterious binding influence. This is very satisfactory, if the properties of β-rays are the only facts to be considered, because the necessary modification of the classical theory is in this case very simple and reasonable. It is perfectly evident, however,[13] that the exact form of the necessary modification of the classical theory was only arrived at by first considering the problem according to method 1.

As we pass from a consideration of the β-rays to the problem of electrons in the atom, we find that the Lorentz electron fails entirely to explain the experimental data. Some of the difficulties have already been mentioned, and have led to the conception of a ring electron. The problem, however, which has attracted most attention in this field for the past ten years is a certain mysterious discontinuity in the action of electrons in the atom.

It is surprising that nearly all physicists have attacked this problem by method 2 instead of testing thoroughly method 1, which has given perfectly satisfactory results in explaining the properties of β-rays. Besides the fact that the newly invented discontinuous force laws and "parcels of energy" are directly contrary to the empirical principle of continuity of dynamical effects and represent the law of variation with the inverse square of the distance as more of a "statistical" coin-

[12] The Lorentz electron is unchangeable as viewed from the standpoint of the relativity principle.

[13] Lorentz, H. A., Konink. Akad. Wetensch. Amsterdam, Versl. 12 (1904) 986; Theory of Electrons, 217.

cidence than a fundamental principle,[14] we have very good evidence that the classical theory is valid for distances much smaller than the radius of an atom. It has been experimentally verified for positive nuclei (containing both positive units and electrons) at distances[15] of about 3×10^{-12} centimeters.

It is the purpose of this paper to point out the value of the theories of atomic structure which are based on method 1, and to suggest further possible lines of advance along this road. The best empirical expression of the mysterious discontinuity referred to has been given by Planck, whose quantum theory will now be briefly reviewed.

PLANCK'S QUANTUM THEORY

Planck's theory, proposed in 1901,[16] has been recently presented by him as follows:[17] Water waves on an inclosed area are reflected from shore to shore with a constant subdivision into shorter waves. If the wind originally causing them ceases, they become converted into smaller and smaller waves until finally all the energy has gone into the form of molecular motion, that is, heat. The classical theory would lead us to expect that similarly confined and reflected light or heat waves would also be converted into very short waves. To continue, in Planck's own words:

> But of such a phenomenon no trace can be discovered in Nature. The conversion sooner or later attains a perfectly definite and assignable limit, and after that, the radiation-conditions remain stable in every respect.
>
> In order to reconcile this fact with the Classical Theory the most varied experiments have already been made, but the result has always been that the contradiction went too deep into the roots of the Theory to leave them unhurt. So again nothing remains but to re-examine the foundations of the Theory. And again we must admit that the principles of Thermodynamics have shown themselves to be unshakable. For the only method so far found to promise a complete solution of the riddle depends directly upon the two laws of Thermodynamics; though it combines with them

[14] Einstein's law of gravitation is sometimes considered as an instance of how a complicated dynamical effect may superficially appear simple. The whole tendency of the relativity theory, however, is to show that observed slightly complicated laws are converted into simple ones by four-dimensional mathematical treatment. No suggestion which could explain a discontinuous dynamical effect is found in the development of the relativity theory,

[15] Geiger, H., and Marsden, E., Phil. Mag. 25 (1913) 604.

[16] Planck, Max, Ann. d. Physik. 4 (1901) 553.

[17] New paths of physical knowledge, Phil. Mag. 28 (1914) 66.

a new and peculiar hypothesis, which, if we utilize the two illustrations above mentioned, can be expressed somewhat as follows:

In the case of the Water waves, the disintegration of the energy of motion is limited by the fact that the atoms hold the energy together, in a way, each atom representing a certain finite material Quantum which can only move as a whole. In the same sort of way certain processes must be at work in the case of light and heat rays, although they are quite of an immaterial nature, which shall hold together the energy of radiation in definite Quanta, and shall unite it the more strongly the shorter the waves and the quicker therefore the frequency of the oscillations.

In what way we are to conceive the nature of quanta of a purely dynamical nature, we cannot yet say for certain. Possibly such quanta might be accounted for if each source of radiation can only emit energy when that energy attains at least a certain minimum value; just as a rubber pipe, into which air is gradually compressed, bursts and scatters its contents only when the elastic energy in it attains a certain quantity.

In any case, the hypothesis of Quanta has led to the idea that there are changes in Nature which do not occur continuously but in an explosive manner. I need hardly remind you that this view has become much more conceivable since the discovery and investigation of Radio-Active Phenomena. Besides, all difficulties connected with detailed explanation are at present overshadowed by the circumstance that the Quantum Hypothesis has yielded results which are in closer agreement with radiation-measurements than are all previous theories.

Planck then emphasizes the fact that the classical theory would lead us to be certain of a fairly constant specific heat for a given solid, even at low temperatures. His theory not only explains why the specific heat becomes almost zero at low temperatures but enables the exact calculation of the specific heats of many substances from their compressibilities.

Planck's hypothesis is that vibrational energy is somehow divided into quanta, the size of which is determined by the frequency of vibration. If ϵ represents a quantum of energy, and ν the frequency,

$$\epsilon = h\nu.$$

h is a universal constant, and has been determined fairly accurately[18] as 6.545×10^{-27} erg-seconds. It is evident that ϵ is not a unit of energy in the sense that the electron is a unit of charge, because it is h, not ϵ, that is constant. Therefore, the hypothesis has in all probability no connection with the innate nature of energy. Nor does it necessarily apply to vibration in general, because it is only in vibrations of high frequency that ϵ is large enough to be appreciable. The only such vibrations

[18] Millikan, R. A., Science 45 (1917) 327.

known are ether waves (infra-red and all shorter waves), electronic vibrations, and atomic vibrations. The questions of whether a vibrating system emits or absorbs energy in quanta and, if so, by what mechanism, have remained for twenty years without a definite answer, but the value of Planck's equation as representing some connection between frequency and the transfer of energy has become established by its signal success in the varied fields of radiation laws, specific heats, spectral series, ionization potentials, and atomic structure.

We have, then, an empirical equation which is at present mysterious, but presumably has an intelligible physical basis in one of three entities, or in some relation between these: the ether, the electron, or the positive unit. These three are so intimately connected in nature that no one has been able so far to point out just where the discontinuity lies.

Theories have been advanced that a wave front of light (or other ether wave) is discontinuous, and only follows the classical equations approximately.[19] It is generally admitted, however, that there is no incompatibility between Planck's equation and the classical theory of the propagation of waves in free ether.

Jeans,[20] after a mathematical analysis of the situation, says that "we are called upon to revolutionize views which have long been regarded as well-established on the nature or meaning of electricity, ether, or radiation." He cannot show just what view must be revolutionized, however. One of his assumptions has to do with the structure of the electron, which one may perhaps be excused from regarding as well-established.

The favorite method of attempting to explain Planck's equation seems to be in assuming "discontinuous force laws" at small distances, or that "tubes of force" are definite actual realities instead of convenient conceptions.[21] It is impossible to say that any of these views is incorrect or absurd; but better results, both in arithmetical calculation and physical intelligibility, seem to have been arrived at by those physicists who have modified the classical theory as little as possible. Among these Bohr [22] has achieved the most marked success in construct-

[19] Einstein, A., Ann. d. Physik. 17 (1905) 132; Thompson, J. J., Proc. Camb. Phil. Soc. 14 (1906–8) 417.

[20] Jeans, J. H., Phil. Mag. 27 (1914) 22.

[21] Thompson, J. J., Phil. Mag. 30 (1917); 37 (1919) 419; 39 (1920) 679–90; Langmuir, I., Journ. Am. Chem. Soc. 41 (1919) 932, and many others.

[22] Bohr, N., Phil. Mag. 26 (1913) 1, 476, 857.

ing an arithmetically correct hydrogen atom, and Parson [23] and Webster [24] in suggesting a possible physical basis for the supposed discrepancies between radiation and the classical theory. Lewis [25] and Langmuir [26] have succeeded in establishing the gross structure of the atom by a judicious combination of physical and chemical data.

THE REAL PROBLEM

A man looking through a telescope may fail to see what is in his hand. Therefore, it is necessary to state a problem before we can work at it intelligently. Some persons enjoy delving into the *effects* which an object produces, and others, into the *construction* of the object. Now each of these points of view is necessary for the advancement of science. Either without the other is absolutely helpless. We know nothing of objects except from their effects, and on the other hand the most profound mathematician could never disregard *structure* entirely and write an equation representing the summation of the *effects* of the universe upon his consciousness at any instant.[27]

Although it is impossible to prove on a basis of *pure* logic that we can obtain a true conception of any object in the universe it is equally impossible to prove that we cannot. *Common-sense* logic not only tells us that we can, but has justified its stand by the present development of science, which would have been absolutely impossible without it.

Now common sense must always be open to correction, but it has always divided objective realities into two classes, which may be called independent and dependent. A rifle bullet, for example, exists independently of its kinetic energy, but common-sense logic tells us that kinetic energy is a *property* which the bullet may or may not possess. We can say that the bullet has kinetic energy, or momentum, or entropy, or a property defined as energy divided by entropy, or a property defined as acceleration multiplied by radius, and so on ad infinitum, but it is still the same bullet. There is no possibility of denying that certain

[23] Parson, A. L., Smithsonian Miscellaneous Collections 65 (1915–6) No. 11.

[24] Webster, D. L., Proc. Am. Acad. 50 (1915) 131; Phys. Rev. 13 (1919) 305.

[25] Lewis, G. N., Journ. Am. Chem. Soc. 38 (1916) 762.

[26] Langmuir, I., Journ. Am. Chem. Soc. 41 (1919) 868, 1543; 42 (1920) 274.

[27] Except for those times when Σ effect $= 0$.

of these conceptions are very valuable, and certain relations between them, such as the law of conservation of energy (especially if we are particular always to define energy in such a manner that this law will not be violated), are fundamentally necessary to science. The fact, however, that one could in a single day define as many as a thousand such conceptions hitherto unused, and could spend a lifetime in developing new equations expressing the relations between these quantities, even if they all applied only to a single rifle bullet considered as a rigid body, should prevent us from setting up any such conception or any such relation as a "graven image to bow down and worship it."

Presumably none of our ideas are absolutely correct, but common-sense reasoning tells us that some, like Euclid's and Maxwell's laws, are intimately connected with the real structure of the universe; while others, like the statement that the entropy of a system always tends to a maximum, or $\epsilon = h\nu$, bear distinct trademarks of human manufacture. I think Minkowski has conclusively demonstrated the value of considering that our concept of space is only a partial view of a more fundamental four-dimensional construction of the universe. I may add that it does not follow that time is not an entity independent of this four-dimensional construction. For we can measure time in absolute units (see following paper) wherever we may be situated in this four-dimensional construction, from which fact I can form no other conclusion but that time, if correctly defined, is independent of the four-dimensional construction. However this may be, the four-dimensional construction has not shaken our faith that Maxwell's and Euclid's laws represent close approximations to the fundamental construction of the universe, but rather has increased our reason for belief that these laws, in the extended four-dimensional forms (which, for the purposes of the present paper, are equivalent to the three-dimensional forms with the Lorentz transformation), are very fundamental. Therefore, it seems to me the height of folly so to concentrate our attention on one of the laws of the second class mentioned that we fail to apply to our problems the known laws which are of a much more fundamental nature.

Common-sense logic (which of course is always subject to correction) tells us that a light wave is the motion of something caused by the motion of something else. If we find a peculiar relation between light waves, it is natural to refer it to the properties of one of these things. It has been for some

time quite evident that the formula, $\epsilon = h\nu$, and the structure of the atom have some intimate relation with each other. It seems to me that the only reason that physicists have not long ago discovered the exact nature of this relation is that they tried to explain one single property of a complex object, the atom, before seriously considering how it is put together. The structure of the atom was a difficult problem before the discovery of electrons, and even yet is not a solved problem; but the nature of the most successful hypotheses on this subject, and some considerations which will be discussed later in this paper, make it seem very probable that the solution could have been entirely deduced from the classical electromagnetic theory and the experimental evidence available twenty years ago. In speaking of the classical theory I refer to the experimentally verified simple laws which were developed in the nineteenth century concerning the properties of electricity. The difficulty was not due to lack of evidence or lack of theory; it was caused by the introduction of entirely gratuitous assumptions concerning the spacial distribution of electricity in an electron.

It was well known in 1900 [28] that an atom could not be explained on the basis of point nuclei and the electromagnetic theory. Now why anyone should wish to explain an atom on this basis is a mystery, because a point nucleus is impossible according to the electromagnetic theory. In spite of the fact that the electromagnetic theory was amply justified in every detail by years of experimental work, for some reason it has not been this theory, but the fixed idea of a point nucleus, upheld by absolutely no experimental evidence, that has dominated practically all attempts to solve the problem of the atom in the last twenty years. Sometimes the idea of the point nucleus has been discarded, but generally with a corresponding disregard for the electromagnetic theory.

Now I am far from claiming that the classical theory is infallible, even in its present four-dimensional form, but I can see no objection to using it as a working hypothesis until there is some reason to doubt its validity. The fact that such arbitrary and apparently impossible assumptions as infinite velocity, point nuclei, or Lorentz electrons are incompatible with it appears to me to be in no way a reflection on the validity of the classical theory.

[28] Larmor, J., Aether and Matter. Cambridge University Press (1900).

The real problem of physics for the past twenty years has not been to show how matter is nothing but a form of energy, or that the entropy of the universe is constantly increasing, or to explain $\epsilon = h\nu$, but to explain how positive and negative units of electricity combine to form atoms. It is very easy to obtain a possible partial solution of this problem if one states it clearly as follows:

1. Given that atoms contain positive and negative units of electricity, and so far as we know nothing else.

2. Given the classical electromagnetic equations as a working hypothesis to be applied to the interpretation of experimental data.

3. To find an explanation for the stability and definiteness of atoms.

A MECHANICAL CONCEPTION OF THE POSITIVE AND NEGATIVE UNITS

For the purposes of the argument here presented no particular mechanical concept of the electron is necessary, but if we use the term "ether" in the sense defined by Cunningham [29] and "space" in the sense used by Einstein,[30] we can obtain a mechanical concept which is fairly accurate. A positive unit is thus a small cavity in space, from which ether is continually proceeding, presumably from some sphere beyond the confines of our knowledge. The flow of ether is constant and its tension is constant, presumably due to a kind of resistance which it meets in passing through the surface of the cavity. The only way of conceiving of the effect due to this tension is to consider space projected down to two dimensions. It then becomes like a rubber band being pulled through a sheet of paper, which causes a local distortion of the sheet. The attraction which two distortions in the same direction would naturally have (cf. the paper analogy) for one another is comparable to Einstein's expression for gravitation.

According to this view an electron is a larger cavity through which ether escapes from our space, having accomplished its purpose, so far as we are concerned, of tending to bring positive and negative units together.

[29] Cunningham, E., Relativity and the Electron Theory. London, Longmans, Green & Co. (1915), 92.

[30] Einstein, A., Ann. d. Phys. 354 (1916) 769.

AN EXPLANATION FOR THE STABILITY AND DEFINITENESS OF ATOMS

Whatever be the ultimate nature of electrons, they are bodies having apparently constant electric charge and probably constant mass (if mass is defined properly from a relativity standpoint), but no evidence has ever been found that they have constant shape under different conditions. So far as I know the Lorentz electron, which is a rigid sphere from a relativity standpoint, satisfactorily represents electrons which are in uniform motion or in uniform acceleration; but it is not satisfactory for any case of an electron in nonuniform acceleration, such as, for instance, any electron in an atom. Some, at least, of the electrons in atoms are known to have magnetic effects, and the facts of radio-activity teach us that even nuclei contain electrons in extremely rapid rotation. These properties are not accompanied by that steady loss of energy by radiation which the classical theory tells us that Lorentz electrons in orbits would give. The classical theory tells us that to produce such results electricity must be in a form of motion which does not cause its distribution in space to vary. It is not necessary to point out the reasons why a rotating disk, or hollow sphere, or other shapes of circular symmetry would not give effects corresponding to experimental data. Whether they do or do not, a thin circular ring, rotating about its center, would undoubtedly give magnetic effects without radiation.

Now I am far from assuming that an electron is a ring. But I object to the assumption of an electron of any shape which is perfectly rigid (as the Lorentz electron is from a relativity standpoint). We cannot assume that an electron has any absolutely unchangeable shape without involving a contradiction of that principle of common-sense logic which says that a physical cause and its effect cannot exist in different places at the same time. If we do not assume an absolutely unchangeable shape we must assume some force or influence which holds the electric charge together. Making the least assumption possible, namely, that there is such a force, but that we do not know anything about its magnitude, we find that any electron in any nonuniformly accelerating field will be distorted in a manner similar to the tide producing distortion of the earth, which is familiar to all of us. Since we have made no assumption as to the strength of the forces which

resist distortion in an electron we find that, whatever the shape of the electron at rest, tidal streamers [31] may be formed when it approaches close to a positive nucleus. It is reasonable to suppose that two streamers may become united, probably by the very close approach of both to the nucleus. We certainly have no reason to assume, as has been assumed, that the influence confining an electron is so strong that a ring cannot thus be formed.

Whether formed in this manner or in some other, it is quite evident that a ring, or some similar shape, exists. We also know that electrons in atoms are in quite definite stable positions or orbits, of which there are two types, those inside the nucleus and those outside the nucleus. Now it may easily be shown that a ring of electricity, rotating about a positive nucleus, will in general be a variable ellipse, unless there is a definite stabilizing force. The instability may be expressed in this way, that a displacement, relative to the ring, of the nucleus in the plane of the ring (of course really the ring moves more than the nucleus) causes a wave of longitudinal and transverse distortion to proceed along the circumference of the ring with a velocity the same as that of the rotation. We may assume that this wave does not produce instability because it is checked by the unchangeable shape of the ring, but the spectral evidence of a thousand or more different definite states indicates that it is checked by a vibrational wave from the same source traveling in the opposite direction around the ring and with the natural velocity of vibrational propagation in that ring. The stable states for such vibrations are those in which the circumference of the ring contains one, two, three, four, etc., complete wave lengths of vibrations, so that standing waves can be set up. Any disturbing influence up to a certain limit may accordingly be supposed to increase the energy of the standing waves, without interfering with the definite character of the state of motion. The most stable states are those in which there is a single standing wave. Of these there are two types to be expected, because the velocities of longitudinal and transverse vibration in rings are different. I suppose that the transverse vibrations determine the stable state inside the nucleus, and the longitudinal vibrations the state outside of the nucleus.

[31] Cf. Chamberlain, T. C., Carnegie Inst. of Washington Year Book 3 (1904) 195.

According to this view a hydrogen molecule looks somewhat like this ⊙⊙, and a helium *nucleus* the same only something like a thousand times smaller with two extra positive units stably bound because of the high local concentration of negative charge.

So much for pure deduction from the classical theory toward explaining the stability and definiteness of atoms. This could have been done twenty years ago [32] except for the fixed idea of a point electron. In fact the discovery of radio-activity might have been predicted if the electromagnetic theory had been logically applied to the atomic problem in the nineteenth century.

Having found a working hypothesis for the most fundamental part of our problem, namely, for the existence of the atom, we are in a position to return to the spectral lines of the elements, in which there are volumes of information as to the velocities, dimensions, magnetic flux, and internal properties of electrons in atoms. These volumes are somewhat complicated, and a detailed consideration of radiation will be deferred to a later paper. It seems, however, that each spectral series has a limiting frequency, which has an effect on all the lines of the series and often on one line in each of many other series as well. This leads us to infer that each limiting frequency is the frequency of rotation of an electron, upon which other frequencies may be superposed, perhaps by the formation of a vortex ring tangent to the main ring (like a large doughnut on a bicycle tire, if we could put it on).

Whatever the exact explanation of radiation we know from Moseley's [33] work that each atom has a K-series of a very fundamental character, the limiting frequency of which varies approximately with the square of the atomic number. Only one such series is known which is uninfluenced by the presence of more than one electron, namely, the Lyman (K) series of hydrogen. Bohr has shown,[34] however, beyond reasonable

[32] The writer need hardly point out that if the physicists of the nineteenth century were incapable of such a deduction, he himself was infinitely less capable of originally arriving at this result by a process of direct reasoning. The direct method of attack was apparent to him only after several years of mental permutations and commutations of the ideas of a score of physicists, notably the idea of constant angular momentum due to Bohr, who in turn derived it from Planck's quantum theory.

[33] Cf. Millikan, R. A., Science 45 (1917) 323.

[34] Bohr, N., Nature 92 (1913) 231.

doubt, that the fundamental K-frequency for helium with only one electron is exactly 4.0016 times that for hydrogen. Such a close approximation to a very simple relation leads us to infer that the actual laws governing the process are very simple.

Any explanation of the stability of electronic orbits, when applied to the frequencies of the K-series, naturally takes the form of Bohr's "constancy of angular momentum," or something equivalent to it. If *mvr* is a constant for this series, the natural explanation seems to be that the velocity of propagation of waves in the electron ring varies inversely with its radius. The K-series electrons, and probably all stable electrons in atoms may be considered to contain single standing waves, but Bohr's "outer orbits" of hydrogen, and similar partially stable electronic conditions would seem to be determined by the presence of two, three, four, etc., standing waves in the ring.

In conclusion I wish to propose the *vibrating electron ring* as a working hypothesis for the stability and definiteness of atoms which is entirely consistent with the classical electromagnetic laws.

SUMMARY

1. The general methods of attack on the problems of the structure and properties of electrons have been briefly reviewed.

2. It has been pointed out that an interpretation of the outstanding experimental observations in terms of the classical electromagnetic theory leads to the hypothesis of a ring electron vibrating internally in standing waves.

ABSOLUTE UNITS AND THE RELATIVITY PRINCIPLE

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The Relativity Principle, announced by Einstein in 1905,[2] to the effect that if we have any absolute uniform velocity through space we cannot possibly determine it or even detect its existence by the measurement of any known physical quantities, is inconsistent with the nineteenth century ideas of a stationary ether. It is even considered to be incompatible with our intuitions regarding time and space. In spite of these facts, it is generally conceded that the Relativity Principle is a logical conclusion from a mass of experimental evidence. It is further unquestionable that Minkowski,[3] and others following him, have been able to give a more complete mathematical form to the known physical laws by the use of four-dimensional coördinates instead of the usual three-dimensional space which corresponds to our intuitive ideas.

The Relativity Principle has firm foundations, but certain applications which the "relativists" have made of it have not been universally accepted. They claim that *"the phrase 'simultaneous events at different points' has no meaning until the velocity of those points is stated."*[4] This would not be so serious in itself, but they proceed to deduce from this alleged fact that we cannot possibly have any absolute units of length, time, or mass, and devise complicated "clock" and "light-signal" systems for defining various units of "times." Crehore [5] and others have pointed out the absurdity of such ideas, and the present paper

[1] From an address before the Freer Club, Manila. Received for publication April 15, 1921.

[2] Einstein, A., Ann. d. Physik. 322 (1905) 891.

[3] Minkowski, H., Raum und Zeit, Phys. Zeit. 10 (1909) 104; cf. Cunningham, E., Relativity and the Electron Theory, London, Longmans, Green & Co. (1915); cf. also Einstein A., Ann. d. Physik. 354 (1917) 769.

[4] Cunningham, E., op. cit., 29; cf. also Eddington, A. S., in the relativity symposium in Nature 106 (1921) 781–813. This interesting collection of articles came to the writer's attention after the present paper went to press.

[5] Crehore, A. C., The Mystery of Matter and Energy. New York, Van Nostrand Co. (1917) 51.

is a somewhat detailed extension of the "non-relativists'" arguments upon this subject.

The fundamental fallacy of the relativists seems to be due to the fact that the Relativity Principle happened to be discovered by certain experiments on the velocity of light. Now the Relativity Principle states that it is impossible to detect by the measurement of *any* physical quantity our absolute motion through space. Therefore, *all* physical quantities are *apparently* unaffected by our absolute motion through space. If a single exception to this rule should ever be found, the Relativity Principle would lose forever its physical significance.

From the standpoint of present-day knowledge there is absolutely no reason to consider that the velocity of light is in any way more dependent upon an electromagnetic medium (the ether) than are any of the physical quantities usually considered the properties of matter, with the possible exception of gravitation. It is universally conceded that part, if not all, of the mass of matter is electromagnetic in origin and behavior, and that part, if not all, of the forces of chemical union, cohesion, and elasticity are of this same nature. Certainly the apparent mass of a rapidly moving electron varies enormously with its speed through the electromagnetic medium, if we measure it when the electron is moving relative to us; and, if the force between two electric charges were not subject to the same variation, we would not teach in our schools that magnetism is the effect of electricity in motion. The Relativity Principle states that all of these quantities, though apparently variable if we do not move along with the object in question, are apparently constant, as far as the motion of the object is concerned, if we do move along with it.

Our problem, therefore, is as follows:

It being given that the following quantities are not affected by the motion of the earth through space.

1. The apparent velocity of light in our vicinity, from whatever source;

2. The apparent mass of an electron in our vicinity, from whatever source;

3. The apparent mass of a positive nuclueus;

4. The apparent charge of an electron;

5. The apparent density of water (under definite pressure and temperature);

6. The apparent hardness of the diamond;

7. The apparent compressibility of sulphur dioxide (under definite pressure and temperature);

8. One thousand and one apparent physical quantities that we can measure;

To find:

1. Absolute units of length, time, and mass such that, if we should send our experimental data on the density of water to a scientist on a planet of Sirius, he could interpret the results *without any reference to his velocity relative to us.*

2. A criterion of *absolute* simultaneity at two different points which shall not involve the velocity of those points.

Now if Bucherer's experiment on the mass of an electron had preceded the Michaelson-Morley experiment on the velocity of light, I suppose the principle of relativity would have been deduced from the constancy of the Mass of an Electron, as it certainly could have been, because if the mass really varies with the absolute motion through space we would get very different results for one electron going along with the absolute motion of the earth and another going against this absolute motion.

Similarly if some brilliant physicist had discovered that the compressibility of sulphur dioxide was remarkably constant, whether taken in the direction of the earth's absolute motion or across it, the principle of relativity might have been founded on the constant Compressibility of Sulphur Dioxide.

As it happened, however, the relativity principle was discovered by means of experiments on the Velocity of Light, so the relativists set up the constancy of the velocity of light as a "graven image," and commanded the rest of the world to come with them into the mud of "ambiguity," "clocks," and "light-signals," and worship it.

It seems to me that there is only one conclusion that we can arrive at from the data that have just been stated. It may be wrong, of course, and some other conclusion may be right; but wrong or right, the other conclusion was obtained from some other sources than the experimental data. The conclusion that corresponds to the data is that every item given represents a *natural constant* which is *absolutely* independent of uniform motion through space. Whether we draw this conclusion or not, we can solve the problem, as stated.

If an umpire were required to measure a baseball, he would hardly attempt the feat while the ball was speeding toward him from the pitcher's hand. He would first get it in his hand, at rest, as far as he is concerned, and then measure it. A scientist has an advantage over the umpire, in that he can measure the properties of things which are in motion relative to him; but if he does so, and if they are moving very fast, he must apply a correction to his results which is known as the Lorentz transformation.

Now if a scientist wishes to define his units in an *absolute* manner he naturally measures something which is at rest relative to him, so that he can be sure of his results.

There are certain quantities which involve motion, and are therefore inconsistent with relative rest, but he has a wide range for the practical constancy of these quantities, which becomes a theoretical constancy in the limiting case. The conditions for the measurement of the velocity of light do not bother him, because our premise states that this value, if measured in his vicinity, is apparently a constant. He must still be cautious, however, and measure only light in his immediate vicinity. If he tries to measure the velocity of light on some body that is moving relative to him he still must correct his measurements.

The relativists claim that a unit of length, time, or mass is meaningless except for a "frame having a certain velocity." Does that mean that my measurement of the density of water to-day is meaningless to-morrow when my "frame of reference" is different? "Oh, no," they say, "the *numerical* value of the measurement will still be good, but both the density and the size of your units will have changed without your knowledge. You cannot compare to-day's units or to-day's actual density with to-morrow's units or to-morrow's actual density without a knowledge of your velocity to-day relative to your velocity to-morrow."

This statement is fallacious. There are many ways in which we can define our units of length, time, and mass, in terms of absolute units which are not affected by the velocity of "frame." Without saying anything about the *absolute* mass of an electron, we have given, from the Relativity Principle itself, that the *apparent* mass of an electron, properly measured, is a constant not affected by change of "frame." We have given the same as to the apparent charge of an electron and the apparent velocity of light.

Let us define a gram as this apparent mass of an electron multiplied by $\frac{10^{28}}{9.01}$. The manner specified for measuring the mass of the electron (that is, that the electron shall be at rest relative to the observer), does not specify any *particular* "frame" for the observer and electron. The apparent mass so determined is constant according to the Relativity Principle itself. The pure number $\frac{10^{28}}{9.01}$ can hardly be expected to vary with the "frame," so we have an *absolute* definition of the gram, in the sense that every quantity in it is independent of the "frame."

An absolute unit of length may be similarly obtained from the known properties of a system of two electrons at rest relative to the observer. If they are at rest at an apparent distance L_1, which we need not measure in any units, after a short apparent time the apparent distance between them will be increased by a length L_2. During the same time any light wave in the neighborhood will have apparently moved a distance which we will call L_3. Now we know that as we choose the interval of apparent time shorter and shorter, the apparent length $\frac{L_1^2 . L_2}{L_3^2}$ approaches a constant value absolutely independent of our "frame" in space, provided only that there is no relative motion between us and the electrons. We may now define a centimeter as a length which contains $\frac{9.01 \times (2.9986)^2 \times 10^{12}}{(4.774)^2}$ of these absolute length units.[6]

The second may now be defined as the apparent time required for light to travel 2.9986×10^{10} centimeters. Now these units are all apparent quantities, but they are also absolute,

[6] The above numerical relation of the centimeter to this absolute unit is arrived at as follows:

$$\text{acceleration of each electron} = \frac{e^2}{m L_1^2}$$

$$\text{velocity of each} = \frac{e^2 T}{m L_1^2}$$

$$\lim_{T=0} \left[\frac{L_2}{T} = \frac{e^2 T}{m L_1^2} \right]$$

$$L_3 = cT$$

$$\lim_{T=0} \left[\frac{cL_2}{L_3} = \frac{e^2 L_3}{m L_1^2 c} \right]$$

$$\lim_{T=0} \left[\frac{L_1^2 L_2}{L_3^2} = \frac{e^2}{mc^2} \right]$$

in the sense that they are entirely independent of the "frame of reference" of the quantity to be measured. The only specification is the manner in which quantities shall be measured when using these units.

The question remains as to whether units thus defined would be intelligible to an observer on a planet of Sirius if he did not know his relative velocity, and without the use of "light-signals." Certainly, when we have the comets under better control we can write the definition in Inter-stellar Esperanto and mail it to him. I see no reason why his electrons should not have the same apparent properties as ours. If they do not it would be necessary for him to remove some of the "Earth" electrons from the letter we send and measure their apparent properties. The Principle of Relativity tells us that these would not have changed in changing the "frame of reference."

With units independent of "frame" the problem of simultaneity is simple. It is generally admitted that a position-time coincidence is a simultaneity. But after this coincidence, time keeps "flowing on," as Newton said, for each particle in the same absolute units. Therefore any two particles which ever have been together have absolute simultaneity, measured by the number of seconds which have elapsed since their coincidence. Similarly these particles may impart their absolute simultaneity to other particles by coincidences with them, and therefore any two bodies possess absolute simultaneity if any connection between them has ever been established by coincidences. To suppose that they really do not possess this property unless they have been so connected is to assume that the smallest particle may have an enormous effect on the largest star.

I would not dwell so minutely on this subject but for the pernicious and widespread effect that the "light-signals" doctrine has had and is still having. I hope I have been able to show that it is in no sense a true representation of the Principle of Relativity. There is no necessity for allowing our intuitions to prejudice us against the Relativity Principle. On the other hand there is no excuse for allowing the Relativity Principle to prejudice us against the very valuable concept that there are certain fundamental quantities in the Universe which we can measure with our somewhat imperfect ideas of length, mass, and time.

SUMMARY

1. It is pointed out that the velocity of light is only one of many physical quantities, equally electromagnetic in nature, which are apparently not affected by the motion of the earth through space.

2. In view of this fact it is a fallacy to assume any one of these quantities to be a Universal Constant and to deduce from this assumption that the others are not real constants but only apparent constants.

3. Whatever view we take of the situation we can define our units of length, time, and mass in such a way as to make them independent of the velocity through space of the system considered, and it follows that absolute simultaneity is definable.

NEW COLEOPTERA FROM THE PHILIPPINE ISLANDS

FAMILY BUPRESTIDÆ, TRIBE AGRILINI

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This paper is based on part of a collection of Buprestidæ received from Prof. Charles Fuller Baker, College of Agriculture, University of the Philippines, Los Baños, P. I., together with the material in the collection of the United States National Museum, Washington, D. C.

Material from the Malaysian region was not well represented in the Museum collection, and most of the species mentioned in the present paper have been collected by Professor Baker on various islands of the Philippine Archipelago. The collection is especially rich in the smaller species of the family, and as these minute forms are seldom taken by the average collector, they are usually not very well known. It is, therefore, necessary to describe a number of these as new. The present paper is confined to the tribe Agrilini, which includes nearly all of the smaller Buprestidæ and is the largest tribe of the family, including over one-third of all the described species.

Very little has been written on the habits of this tribe from the Philippines; one species, *Agrilus occipitalis* Esch., has been reported as injuring branches of lemon and orange trees, and other species will be found of great economic importance just as soon as their habits are known.

Through the kindness of Professor Baker, all the types of the new species here described have been placed in the United States National Museum.

I take the opportunity of thanking Professor Baker for having given me the privilege of studying the material of this family from that interesting region.

The keys given in the present paper do not include all the described species from the region, but are only based on the material received from Professor Baker, together with the specimens in the Museum collection. It has been impossible to include these other species, as many of the characters used in the keys are not mentioned in the descriptions by the various authors.

Tribe AGRILINI Castelnau and Gory

Key to the genera.[1]

1. Median coxæ not more widely separated from each other than the anterior ones; anterior margin of posterior coxæ strongly concave; tarsi more or less elongate ..... 2.
   Median coxæ more widely separated from each other than the anterior ones; anterior margin of posterior coxæ feebly concave; tarsi very short ..... 12.
2. Eyes large, touching pronotum ..... 3.
   Eyes small, placed a certain distance from pronotum. Cylindromorphus Kies.
3. Antennæ free in repose ..... 4.
   Antennæ inserted in a prosternal groove in repose .. Neosambus gen. nov.
4. First joint of posterior tarsi short, rarely as long as the following two joints united ..... 5.
   First joint of posterior tarsi as long as or longer than the following two joints united ..... Agrilus Steph.
5. Antennæ serrate, beginning at the fourth joint ..... 6.
   Antennæ serrate, beginning at the fifth or sixth joint ..... 9.
6. Lateral margin of pronotum smooth ..... Melibaeus Deyr.
   Lateral margin of pronotum crenulate ..... 7.
7. Prosternal lobe short, more or less lobed on sides ..... 8.
   Without prosternal lobe ..... Coraebus Cast. and Gory.
8. Pronotum with disk convex and smooth ..... Cisseicoraebus Kerrem.
   Pronotum with disk uneven and indented ..... Amorphosoma Cast.
9. Femora normal ..... 10.
   Femora robust, dentate on the inner side ..... Sambus Deyr.
10. Tibiæ dilated for insertion of tarsi in repose .... Cryptodactylus Deyr.
    Tibiæ not dilated for insertion of tarsi ..... 11.
11. Tibiæ arcuate, leaving a space between them and the femora. Toxoscelus Deyr.
    Tibiæ straight ..... Neotoxoscelus gen. nov.
12. Tibiæ free in repose ..... 13.
    Tibiæ received in a deep groove in repose ..... 14.
13. Base of pronotum truncate; eyes parallel ..... Paratrachys Saund.
    Base of pronotum sinuate; eyes oblique ..... Trachys Fabr.
14. Epistoma wide; antennal cavities far apart ..... Anthaxomorphus Deyr.
    Epistoma narrow; antennal cavities close together ..... 15.
15. Antennæ with joints 8 to 11 forming a distinct club. Aphanisticus Latr.
    Antennæ normally dentate, not forming a distinct club .. Endelus Deyr.

Genus CYLINDROMORPHUS Kiesenwetter

Cylindromorphus orientalis Kerremans.

This species is represented in the United States National Museum collection by three specimenes; two labeled "Acc. No.

[1] *Melibaeus aeneifrons* Deyr., *M. bakeri* Kerrem., and *Cisseicoraebus grandis* Kerrem. have been described from the Philippines, but I have been unable to examine any of these species.

986, Bur. Agr. P. I., collected by C. R. Jones" and "Acc. No. 1667 Bur. Agr. P. I., collected by C. R. Jones," all specimens without any definite locality. The Bureau of Agriculture reports that the locality for these numbers is Lamao, Bataan Province, Luzon.

These specimens agree with the original description with the exception that they are of a uniform bronzy color.

Genus **NEOSAMBUS** novum

Form of *Sambus*. Head strongly convex; cheeks unarmed; antennal cavities rather large, oblique, widely separated and situated a little distance from the inner margin of the eyes. Antennæ short, serrate from the fifth joint; joints one and two robust, the second shorter; third and fourth more slender and about subequal in length; following joints strongly serrate on the inner margin. Eyes large, oval, distinctly more remote on occiput than at base. Pronotum wider than long, disk uneven, without lateral carina; lateral margin feebly crenulate. Scutellum visible. Elytra convex, without distinct basal depressions; sides sinuate and expanded behind middle. Prosternum with two large lobes in front, concealing the sides of the mouth; deeply grooved along sides for insertion of antennæ in repose. Intercoxal process elevated and abruptly bent downward at apex. Pygidium broadly projecting behind tips of elytra, strongly, longitudinally carinate at middle, the carina angular and strongly elevated. Metasternum deeply emarginate in front. Middle coxæ not more widely separated than the anterior ones. Posterior coxæ deeply concave behind, nearly straight in front, with the lateral margin strongly dilated posteriorly. Femora moderately flat, arcuately narrowed toward apex, the inner margin with a few very strong teeth. Tibiæ very feebly arcuate and subcylindrical, the posterior one ciliate on the posterior margin. Tarsi very short, first joint about equal in length to the second; claws bifid at base, the lower portion touching that of the opposite side.

Genotype, *Neosambus cupricollis* sp. nov.

This genus superficially resembles *Sambus* Deyr., but can be easily separated from that genus by having the sides of the prosternum deeply grooved for the reception of the antennæ in repose. In structure it is rather closely allied to the genus *Kamosia* Kerrem., from Africa, but the cheeks are unarmed while in that genus they are armed with a sharp tooth. In *Neosambus* the antennæ are serrate from the fifth joint, while in *Kamosia* the serration begins at the fourth joint.

Key to the species.

1. Above pubescent; elytra with transverse pubescent bands. N. ornatus sp. nov.
   Above glabrous ..... 2.
2. Head feebly, longitudinally grooved ..... N. cupricollis sp. nov.
   Head without longitudinal groove ..... 3.
3. Elytra strongly expanded behind middle and of a bottle-green color. N. viridipennis sp. nov.
   Elytra feebly expanded behind middle and of a reddish violaceous color. N. glabrus sp. nov.

Neosambus cupricollis sp. nov.

Elongate, robust and strongly convex, shining; head and pronotum bright cupreous, becoming brassy on front of head; elytra and beneath bright greenish blue, glabrous.

Head with the front wide, strongly convex, feebly gibbose on the vertex, with a feeble, median, longitudinal groove on vertex and occiput, becoming obsolete on middle of front; surface strongly strigose, the strigæ transverse on the front and becoming concentric on the gibbosities; intervals with large, shallow punctures; epistoma transverse, anterior margin broadly but not deeply, arcuately emarginate, the angles extending beneath the antennal cavities; clypeal suture transverse, elevated. Pronotum one-half wider than long, widest at about the middle, slightly narrower in front than behind; sides feebly margined and crenulate, strongly arcuate from apex to basal sixth, then nearly straight to the posterior angles, which are nearly rectangular; anterior margin deeply emarginate, with a large, broadly rounded lobe at middle, the angles acute; base strongly bisinuate with a large median lobe, which is truncate in front of scutellum; disk strongly gibbose behind the middle; surface with a broad, irregular depression along the lateral margin, extending from apical sixth to base, coarsely, transversely rugose, except on the gibbosities, where the rugæ are more or less concentric, intervals smooth, with elongate punctures connected posteriorly to the rugæ. Scutellum triangular, very acute posteriorly; surface smooth. Elytra as wide as pronotum at base, strongly convex; humeral angles obtusely angulate; sides strongly sinuate at posterior coxæ, broadly expanded just behind the middle, then arcuately narrowed to tips, which are separately, broadly rounded and finely dentate; surface very coarsely, transversely rugose, becoming much smoother toward apex, intervals with coarse, elongate punctures behind the rugæ. Abdomen rather convex, glabrous, rather densely marked with distinct crenulate lines; prosternum coarsely scabrous and

sparsely pubescent; intercoxal process nearly parallel to behind coxæ, then abruptly narrowed to apex, which is acute; tarsi and claws black; tarsal lamellæ brownish.

Length, 6.1 millimeters; width, 2.25.

Described from a single specimen from Davao, Mindanao (*C. F. Baker*).

Neosambus ornatus sp. nov.

Elongate, subparallel, moderately convex, uniformly piceous, with a feeble greenish tinge on elytra; head with the front cupreous; elytra ornamented with transverse pubescent bands.

Head with the front wide, convex, not gibbose on vertex, with a vague median longitudinal groove, extending from occiput to the clypeal suture, which is transversely truncate; surface very sparsely, coarsely punctate, and sparsely pubescent; epistoma transverse, anterior margin broadly, but not deeply, arcuately emarginate, the angles extending beneath the antennal cavities. Pronotum three-fourths wider than long, widest at about the middle, base and apex about equal in width; sides feebly crenulate and evenly, arcuately rounded; anterior margin moderately emarginate, with a broadly rounded lobe at middle, the angles acute; base bisinuate, with a broadly rounded lobe in front of scutellum, the angles obtusely rounded; disk rather evenly convex, with a broad, inconspicuous depression posteriorly along the lateral margin; surface sparsely, coarsely punctate and feebly strigose, sparsely clothed with long, white and brown, recumbent pubescence. Scutellum transversely triangular; surface smooth. Elytra as wide as pronotum at base, strongly convex; humeral angles strongly angulate; sides sinuate at posterior coxæ, broadly expanded behind middle, then arcuately narrowed to tips, which are separately, broadly rounded; surface strongly, transversely rugose and rather densely punctate, the punctures and rugæ becoming finer toward apex, sparsely clothed with black and silvery white pubescence, the white pubescence forming designs on each elytron as follows: A broad oblique band extending from humerus to suture at basal fourth, a wide transverse band just behind the middle, and a narrower transverse band near apex. Abdomen rather convex, sparsely punctate and rather densely clothed with long white pubescence; last segment feebly emarginate at apex; prosternum coarsely scabrous and sparsely pubescent; intercoxal process parallel-sided to behind coxæ, then abruptly narrowed to apex, which is acute; tarsi and claws black; tarsal lamellæ yellowish.

Length, 4 millimeters; width, 1.5.

Described from a unique specimen from Iligan, Mindanao (*Baker*).

Neosambus viridipennis sp. nov.

Elongate, rather robust, attenuate posteriorly, strongly convex; head and pronotum bright brassy green; elytra bright bottle green; beneath piceous, shining and glabrous.

Head with the front narrower than in the other species of this genus, strongly convex, not gibbose on vertex, and without median longitudinal groove; sides concave, with the front feebly expanded on occiput, more strongly expanded at anterior margin; surface coarsely, densely strigose, the strigæ transverse on the front, becoming concentric on vertex, intervals with large shallow punctures; epistoma transverse, anterior margin broadly, but not deeply, arcuately emarginate, the angles extending beneath the antennal cavities; clypeal suture transverse, elevated. Pronotum one-half wider than long, widest at about the middle, slightly narrower in front than behind; sides feebly margined and crenulate, strongly, arcuately rounded from apex to middle, then nearly parallel to posterior angles, which are nearly rectangular; anterior margin arcuately emarginate, with a feeble median lobe, the angles acute; base bisinuate, with a large median lobe, which is truncate in front of the scutellum; disk broadly gibbose on the anterior median part; surface with a broad, deep, irregular depression along lateral margin, reaching from apical angles to the base, and a broad, transverse, concave depression along the posterior margin, rather finely, sparsely rugose, the intervals nearly smooth, with a few small punctures connected to the rugæ posteriorly. Scutellum triangular, very acute posteriorly; surface finely strigose. Elytra as wide as pronotum at base, strongly convex; humeral angles obtusely rounded; sides strongly sinuate at posterior coxæ, broadly expanded behind middle, then rather obliquely narrowed to tips, which are separately, broadly rounded, and feebly dentate; surface rather coarsely, transversely rugose, becoming smooth posteriorly, intervals sparsely, coarsely punctate. Abdomen rather convex, glabrous, shining, sparsely and indistinctly marked with crenulate lines; last segment broadly emarginate at apex; prosternum finely, densely scabrous; intercoxal process parallel-sided to behind coxæ, then abruptly narrowed to the apex, which is rather acute, sparsely clothed with long pubescence; tarsi and claws black; tarsal lamellæ yellowish.

Length, 4.25 millimeters; width, 1.4.

Described from a single specimen from Puerto Princesa, Palawan (*Baker*).

Neosambus glabrus sp. nov.

Elongate, rather robust, attenuate posteriorly, strongly convex, glabrous; head green; pronotum dull green, with a violaceous tinge; elytra dark reddish violaceous; beneath aëneous.

Head with the front wide, strongly convex, not gibbose on vertex, without median longitudinal groove; surface rather coarsely, densely punctate and vaguely strigose, feebly pubescent on the front; epistoma about as long as wide, anterior margin broadly, but not deeply, arcuately emarginate, the angles wide and extending beneath antennal cavities; clypeal suture not distinct. Pronotum nearly two times as wide as long, widest at about the middle, narrower in front than behind; sides feebly margined and crenulate, strongly arcuate from apex to basal sixth, then nearly straight to posterior angles, which are nearly rectangular; anterior margin deeply emarginate, with a large, broadly rounded lobe at middle, the angles acute; base strongly bisinuate, with a large median lobe, which is truncate in front of the scutellum; disk strongly gibbose at middle; surface with a broad irregular depression along the lateral margin, which is more deeply depressed just back of the anterior margin, coarsely, tranversely rugose, the rugæ becoming somewhat concentric on the elevated part. Scutellum triangular, very acute posteriorly; surface vaguely strigose. Elytra about equal in width to pronotum at base, strongly convex; humeral angles obtusely angulate; sides sinuate at posterior coxæ, feebly expanded just back of the middle, then strongly, arcuately narrowed to tips, which are separately broadly rounded and feebly dentate; surface very strongly, transversely rugose, the rugæ becoming finer and denser toward apex, intervals with large elongate punctures, connected to the rugæ posteriorly. Abdomen rather convex, glabrous, rather densely marked with distinct crenulate lines; prosternum densely scabrous; intercoxal process parallel to behind coxæ, then abruptly narrowed to apex, which is rather obtuse, rather densely clothed with long white pubescence at middle; tarsi and claws black; tarsal lamellæ brownish.

Length, 4.25 millimeters; width, 1.6.

Described from a single specimen from Mount Banahao, Luzon (*Baker*).

Genus **AGRILUS** Stephens

Key to the species.[2]

1. Elytra spinose at tip ..... 2.
   Elytra not spinose at tip, sometimes strongly dentate ..... 12.
2. Elytra unispinose at tip ..... 3.
   Elytra bispinose at tip ..... 8.
3. Tip of elytron acuminate, spine at middle of apex ..... 4.
   Tip of elytron emarginate, spine on outer angle, sometimes with a very minute spine at sutural angle ..... 6.
4. Pygidium with projecting carina at tip ..... 5.
   Pygidium without projecting carina at tip ..... **A. quadriplagiatus sp. nov.**
5. Elytra with pubescent spaces ..... **A. sexsignatus sp. nov.**
   Elytra without pubescent spaces ..... **A. benguetensis sp. nov.**
6. Claws cleft in such a manner that the lower portion is turned inward, nearly or quite touching that of the opposite side ..... 7.
   Claws simply cleft, the lower portion not inverted ..... **A. ornatus Deyr.**
7. Above bright blue ..... **A. piperi sp. nov.**
   Above green or bronzy green ..... **A. luzonicus Kerrem.**
8. Pygidium with projecting carina at tip ..... 9.
   Pygidium without projecting carina at tip ..... 10.
9. Elytra with transverse dark band at apical third; male without tubercle at middle of first abdominal segment .. **A. nigrocinctus Saund.**
   Elytra with a small dark area at apical third along suture, not reaching lateral margin; male with two small tubercles at middle of first abdominal segment ..... **A. inquinatus Saund.**
10. Elytra with pubescent spaces ..... **A. subspinosus sp. nov.**
    Elytra without pubescent spaces ..... 11.
11. Prothoracic carina short, very arcuate; elytral spines unequal; color blue ..... **A. banahaoensis sp. nov.**
    Prothoracic carina long, nearly straight; elytral spines equal; color bronzy green ..... **A. maquilingensis sp. nov.**
12. Claws cleft in such a manner that the lower portion is turned inward, nearly or quite touching that of the opposite side ..... 13.
    Claws simply cleft, the lower portion not inverted ..... 21.
13. Hind angles of pronotum carinate ..... 14.
    Hind angles of pronotum not carinate ..... 17.
14. Hind tarsi half as long as the tibiæ; form elongate .... **A. occipitalis Esch.**
    Hind tarsi not half as long as tibiæ; form short ..... 15.
15. Intercoxal process elevated along sides ..... **A. albocinctus sp. nov.**
    Intercoxal process not elevated along sides ..... 16.
16. Color above blue to greenish blue ..... **A. subpubescens sp. nov.**
    Head and pronotum green; elytra brown ..... **A. zamboangensis sp. nov.**

[2] The following species of *Agrilus* have been reported from the Philippines but have not been seen by me: *Agrilus abdominalis* Saund., *A. acutus* Thunb., *A. aegnicollis* Esch., *A. atomus* Kerrem., *A. balnearis* Kerrem., *A. discicollis* Deyr., *A. fontanus* Kerrem., *A. pilicauda* Saund., *A. rubifrons* Deyr., *A. semperi* Saund., *A. striaticollis* Kerrem., *A. vilis* Saund., and *A. oreophilus* Fisher (*monticola* Kerrem.).

17. Elytra with pubescent spaces..... 18.
Elytra without pubescent spaces..... 20.
18. Pubescence on elytra forming an inconspicuous vitta.
A. inconstans sp. nov.
Pubescence on elytra forming spots..... 19.
19. Color blue; tips of elytron broadly rounded and dentate.
A. rotundipennis sp. nov.
Color green, shading to cupreous violaceous at tips of elytra, which are narrowly rounded and strongly dentate..... **A. bakeri** Kerrem.
20. Color above bluish green..... **A. subviridis sp. nov.**
Color above cupreous to bronzy (rubbed specimens).
A. inconstans sp. nov.
21. Hind angles of pronotum carinate..... 24.
Hind angles of pronotum not carinate..... 22.
22. Intercoxal process gradually narrowing; tip acute..... 23.
Intercoxal process expanded behind coxæ; tip broad and emarginate.
A. semipubescens sp. nov.
23. Prosternal lobe arcuately emarginate in front; male with a sharp tooth at middle of first abdominal segment..... **A. subvittatus sp. nov.**
Prosternal lobe broadly rounded in front; male without tooth at middle of first abdominal segment..... **A. fulvovittatus sp. nov.**
24. Pygidium with projecting carina at tip..... **A. innotatus sp. nov.**
Pygidium without projecting carina at tip..... 25.
25. Intercoxal process parallel between and behind coxæ..... 26.
Intercoxal process expanded behind the coxæ..... 30.
26. Head with front deeply impressed..... **A. aguinaldoi sp. nov.**
Head with the front flat or convex; vertex more or less grooved.... 27.
27. Elytra with distinct pubescent spaces..... 28.
Elytra without distinct pubescent spaces..... 29.
28. Prosternal lobe broadly rounded; first joint of hind tarsi one-fifth as long as tibiæ; intercoxal process squarely truncate at apex with acute tooth at middle..... **A. palawanensis sp. nov.**
Prosternal lobe arcuately emarginate; first joint of hind tarsi one-third as long as tibiæ; intercoxal process arcuately rounded at apex.
A. bisignatus sp. nov.
29. Pronotum regularly convex..... **A. tayabensis sp. nov.**
Pronotum with the convexity limited posteriorly by a transverse depression along basal margin..... **A. dapitanensis sp. nov.**
30. Elytra longitudinally carinate behind humeri..... 34.
Elytra not longitudinally carinate behind humeri..... 31.
31. Elytra with transverse dark band at apical third.
A. philippinensis sp. nov.
Elytra without transverse dark band at apical third..... 32.
32. Tip of intercoxal process wide and biemarginate, with the angles very acute..... 33.
Tip of intercoxal process attenuate, with the angles obtuse.
A. attenuatus sp. nov.
33. Last ventral segment rounded at tip; male with intercoxal process longitudinally carinate at middle..... **A. manilensis sp. nov.**
Last ventral segment emarginate at tip; intercoxal process not carinate in the male..... **A. butuanensis sp. nov.**

34. Elytra with transverse dark band ..... 35.
Elytra without transverse dark band ..... 37.
35. Transverse dark band at middle of elytra; last ventral segment rounded at tip ..... A. inermis sp. nov.
Transverse dark band at apical third; last ventral segment emarginate at tip ..... 36.
36. Elytra with basal two-thirds and apical fourth uniformly clothed with white pubescence ..... A. minutus sp. nov.
Elytra with apical fourth and transverse band just behind middle clothed with white pubescence ..... A. pulcher Deyr.
37. Tip of intercoxal process wide and biemarginate, with the angles very acute ..... 38.
Tip of intercoxal process attenuate, with the angles obtuse ..... 41.
38. Eyes converging posteriorly ..... 39.
Eyes not converging posteriorly ..... 40.
39. Form robust; carina on elytra short; elytral pubescence very coarse. A. butuanensis sp. nov.
Form more slender; carina on elytra long; elytral pubescence fine. A. immaculatus sp. nov.
40. Elytra cupreous, with two indistinct white spots along suture near apex; form robust ..... A. malinaoensis sp. nov.
Elytra greenish bronze; form more slender ..... A. iliganensis sp. nov.
41. Eyes converging toward clypeus; hind tibiæ flattened and angulate on outer margin near apex ..... A. davaoensis sp. nov.
Eyes not converging, sides parallel; hind tibiæ not angulate on outer margin ..... A. mindanaoensis sp. nov.

Agrilus oreophilus nom. nov.

In 1906 Kerremans [3] described a species of *Agrilus* from New Guinea under the name *monticola*, and in 1914 he described a species of the same genus from Mount Maquiling, Luzon, Philippine Islands, under the same name. [4] For the species from Luzon I propose the new name *oreophilus*.

Agrilus quadriplagiatus sp. nov.

Female.—Form moderately elongate, robust, front of head cupreous, sides of pronotum and beneath bright aëneous with a strong cupreous reflection; occiput, prosternum, legs, disks of pronotum, and base of elytra dull dark green with a slight purplish tinge, the elytra becoming dark violaceous posteriorly and ornamented with pubescent spaces.

Antennæ shining black, reaching to middle of pronotum, serrate from the fourth joint. Head with the front rather flat, the sides gradually narrowed from vertex to clypeus, broadly and rather feebly, longitudinally impressed from occiput to clypeus;

[3] Deutsche ent. Zeitschr. (1906) 416.
[4] Philip. Journ. Sci. § D 9 (1914) 85.

surface densely, transversely strigose and clothed with a few inconspicuous white hairs, the hairs becoming finer, darker, and almost invisible posteriorly. Clypeus wider than long, with the front margin broadly, arcuately emarginate. Pronotum nearly twice as wide as long, slightly narrowed at base; sides feebly arcuate from apex to base; lateral margin nearly straight when viewed laterally; hind angles rectangular, with a sharply defined, very short, arcuate carina, which does not extend beyond basal fourth; disk convex, with a vague transverse impression behind anterior margin and a similar but deeper one at middle, a deep, oblique, lateral depression joining the transverse median impression; surface coarsely, closely, and irregularly, transversely strigose, the intervals between the strigæ punctate and clothed with short, erect, inconspicuous hairs. Scutellum with a double transverse carina. Elytra rather strongly sinuate behind the humeri, scarcely dilated behind the middle, then obliquely narrowed to apices, these extending into a long acute spine, which is on a line with the middle of the elytron, the outer edge of the elytron before the spine rather strongly serrulate, the inner edge concave, with a few, small, sharp teeth near the suture; sides of the abdomen exposed above; disk rather convex, without distinct costæ, the sutural edge slightly elevated at apical third; humeri prominent, not carinate; basal depression moderately deep; surface shining, finely and densely imbricate, becoming smoother and simply punctate toward apex, sparsely clothed with short, inconspicuous, recumbent hairs, which do not conceal the surface sculpture, each elytron with two round white pubescent spots, one at the middle and the other at the apical third. Body beneath bright aëneous with a feeble cupreous reflection, prosternum and legs dull dark green with a brassy tinge, the former densely, rather coarsely rugose, and sparsely, finely pubescent; prosternal lobe broadly, arcuately emarginate; intercoxal process broad, parallel, and acute at tip; propleura coarsely rugose, not pubescent; metasternum coarsely strigose. Abdomen nearly smooth, feebly, transversely strigose, finely punctate along the edge of the strigæ, third segment with a densely pubescent transverse spot at side; first ventral segment convex, neither impressed nor pubescent; last ventral obtusely rounded at tip; vertical portion of the segments, except the second, densely pubescent; pygidium coarsely punctate, not at all carinate. Hind tarsi five-sevenths as long as the tibiæ, first joint longer than the four following joints united; tibiæ not

mucronate; claws divaricate, rather strongly cleft, the lower portion not inverted.

Length, 11 millimeters; width, 3.75.

Described from a single female from Davao, Mindanao (*Baker*).

Agrilus sexsignatus sp. nov.

Form elongate, parallel, front of head and margin of pronotum green, occiput of head, pronotum except margin, and elytra black, sides of pronotum and each elytron with three yellow pubescent spots, the first filling the basal depression, the second at middle near suture, and the third at the apical third and closer to suture than the middle one.

Antennæ black, with the basal joints slightly bronzy, reaching to middle of pronotum, serrate from the fourth joint; front flat, slightly narrowed toward clypeus; occiput very feebly impressed, the line extending to the middle of the front; surface closely, coarsely punctate, becoming slightly, longitudinally strigose on the occiput, clothed with a few golden yellow hairs on anterior half, becoming denser behind the clypeus. Clypeus wider than long, with the front margin nearly truncate. Pronotum one-third wider than long, distinctly narrower at base than apex, sides slightly sinuate, lateral margin strongly sinuate when viewed laterally, hind angles rectangular, without any trace of carina, disk moderately convex, a moderately deep impression behind the front angles, which is entirely lateral, and a faint antescutellar depression; surface rather finely and densely, transversely strigose-punctate, a broad band of golden pubescence along the lateral margin, the hind angles, however, not pubescent. Scutellum strongly, transversely carinate. Elytra slightly sinuate behind the humeri, with a feeble postmedian dilatation, then gradually narrowed to apices, sides of abdomen exposed above; apices extending into a long acute spine, which is on a line with the middle of the elytron, the outer edge of the elytra before the spine rather strongly serrulate, the inner edge of spine feebly serrulate; disk slightly flattened, with distinct costæ, the sutural edge slightly elevated at apical third, humeri moderate, not carinate; basal depressions well marked; surface subopaque, strongly and densely, imbricately granulate, sparsely clothed with short, inconspicuous, recumbent hairs, which do not conceal the surface sculpture, and ornamented as above. Body beneath with a slight aëneous tinge; prosternum densely, roughly scabrous, and sparsely, finely pubescent; prosternal lobe broadly

rounded, and feebly, broadly, arcuately emarginate at middle; intercoxal process broad, distinctly broadened behind the coxæ, apex broad and biemarginate; propleura densely punctate and sparsely pubescent; metasternum finely rugose. Abdomen rather finely strigose, becoming more coarsely so at the middle of first segment, third segment with a dense golden pubescent spot at sides; first segment convex, not impressed nor distinctly pubescent, with a series of sharp sawlike teeth along the posterior margin on the median line, the teeth feebly elevated and pointing backward; last ventral obtusely rounded and feebly emarginate at tip, vertical portions of the first and third segments covered with dense golden pubescence; pygidium punctate, rather strongly carinate, the carina projecting and truncate at tip. Hind tarsi about one-half as long as the tibiæ, first joint about equal in length to the four following joints united; front and middle tibiæ feebly mucronate at tip; claws divaricate, strongly cleft, the lower portions incurved, those of the anterior and middle tarsi less incurved than the posterior ones, so that the points are quite distant.

Length, 6.25 to 8 millimeters; width, 1.75 to 2.

Described from two specimens, probably males. The type is from Imugan, Nueva Vizcaya Province, Luzon (*Baker*); a paratype is from Puerto Princesa, Palawan (*Baker*).

Agrilus benguetensis sp. nov.

Female.—Form elongate, subcylindrical; head shining, dark olivaceous; pronotum reddish cupreous; elytra dull olivaceous, becoming violaceous posteriorly.

(Antennæ broken off.) Head with the front slightly concave; sides arcuately expanded at vertex, then slightly narrowed toward occiput and clypeus; broadly, longitudinally impressed from occiput to clypeus, the impression becoming deep on the occiput, and with a broad transverse impression in front of clypeus; surface strongly, transversely strigose, intervals sparsely and coarsely punctured, clothed with numerous short white hairs behind the clypeus. Clypeus wider than long, with the front margin broadly, arcuately emarginate. Pronotum two-thirds wider than long, slightly narrowed at base, sides slightly arcuate, lateral margin slightly sinuous when viewed laterally, hind angles rectangular, with sharply defined, slightly arcuate carina, the carina extending to lateral margin near middle, disk moderately convex, a deep, oblique, lateral depression and a broad and rather deep concavity in front of scutellum; surface coarsely,

closely, and irregularly, transversely strigose, the intervals between the ridges punctate and clothed with short, erect, inconspicuous hairs. Scutellum transversely carinate, the carina broadly interrupted at middle. Elytra slightly sinuate behind the humeri, with a feeble postmedian dilatation, then strongly narrowed to apices, sides of abdomen exposed; apices extending into a long acute spine, which is on a line with the middle of the elytron, outer edge of the elytron before the spine scarcely serrulate, inner edge of spine concave, with a few small sharp teeth near the end of suture; disk moderately convex, without distinct costæ, the sutural edge feebly elevated near the apex; humeri moderate, not carinate; basal depressions well marked; surface subopaque, finely and densely, imbricately granulate, rather densely clothed with short, inconspicuous, recumbent hairs, which do not conceal the surface sculpture. Body beneath aëneous, with a cupreous tinge toward the lateral margins; prosternum roughly scabrous and sparsely, finely pubescent; prosternal lobe broadly rounded, feebly arcuately and broadly emarginate at middle; intercoxal process broad, the sides parallel, very abruptly narrowed at apex, which is rather obtuse; propleura slightly strigose and very little pubescent; metasternum coarsely punctate-strigose, the sides densely punctate and rather densely pubescent. Abdomen rather sparsely, coarsely punctate and somewhat strigose along the median line, with very finely and densely punctured areas, midway between the sides and middle, sparsely pubescent; first ventral segment convex, not impressed nor pubescent; last ventral obtusely rounded at tip; vertical portions of the segments not conspicuously pubescent, the first rather strongly granulate, pygidium punctate, carinate, the carina projecting and truncate at tip. Hind tarsi four-sevenths as long as the tibiæ, first joint longer than the four following joints united; tibiæ not mucronate; claws divaricate, cleft at the middle, the lower portion not inverted.

Length, 10.5 millimeters; width, 2.6.

Described from a single female from Baguio, Benguet, Luzon (*Baker*).

Agrilus piperi sp. nov.

Male.—Form short, rather robust, entirely bright blue, with a wide transverse band of sparsely placed, silvery white, recumbent hairs at tip of elytra.

Antennæ short, not quite reaching to middle of pronotum, serrate from the fourth joint. Head with the front concave, sides

arcuately expanded at vertex, then slightly narrowed posteriorly and more strongly toward clypeus; rather deeply and broadly, longitudinally impressed from occiput to clypeus; surface with coarsely placed sinuate striæ and nearly glabrous. Clypeus slightly wider than long, with the front margin broadly, arcuately emarginate. Pronotum one-half wider than long, slightly narrower at base than apex, sides strongly arcuate in front, slightly sinuate behind middle, lateral margin feebly sinuate, hind angles rectangular, with a sharply defined, sinuous carina, the carina rather distant from posterior margin, extending to near lateral margin a little beyond middle, disk moderately convex, with a deep, oblique, lateral depression, and a feeble one in front of scutellum; surface finely and widely striate, the striæ transverse at middle, oblique at sides, intervals broad and shining, the depression sparsely punctate. Scutellum feebly, transversely carinate. Elytra slightly sinuate behind the humeri, broadened behind the middle, nearly entirely concealing the abdomen from above, then obliquely narrowed to apices, these conjointly, broadly, arcuately emarginate, with a short sharp spine at outer angles and a very minute one at sutural angles, the outer edge of the elytra moderately serrulate at apex; disk slightly flattened, without distinct costæ, the sutural edge elevated behind the middle, humeri not prominent nor carinate, basal depressions not very deep; surface shining, densely and coarsely, imbricately granulate, slightly strigose at sides, sparsely clothed with short, inconspicuous, recumbent hairs, which do not conceal the surface sculpture and ornamented as above. Body beneath same color as above; prosternum densely, roughly scabrous, and sparsely, finely pubescent; prosternal lobe broadly, arcuately rounded, feebly truncate in front; intercoxal process feebly broadened behind coxæ, apex truncate, with an acute tooth at middle; propleura scabrous, slightly strigose, and feebly pubescent; metasternum moderately strigose. Abdomen sparsely punctate and transversely strigose, the strigæ coarse at the base, becoming finer toward apex, sparsely clothed with distinct white hairs, third and fourth segments with a more densely pubescent spot at the sides; first ventral segment convex, not impressed nor distinctly pubescent; last ventral obtusely rounded at tip; vertical portions of the first, third, and fourth segments with rather dense pubescent areas; pygidium indistinctly punctate, with a feeble median carina, which is not projecting at apex. Hind tarsi not quite half as long as the tibiæ, first joint about equal in length to the four following joints united; front and middle tibiæ feebly

arcuate, hind tibiæ straight, not mucronate at tip; claws similar on all the tarsi, deeply cleft, the lower portion strongly incurved and touching that of the opposite side.

Length, 8.5 millimeters; width, 1.9.

Described from a single male specimen in the United States National Museum collection, labeled "Lamao, Luzon, P. I., iii–vi, 1911, C. V. Piper collector."

Agrilus ornatus Deyrolle.

Specimens of this species were examined from the following localities: Butuan, Mindanao (*Baker 8356*); Puerto Princesa, Palawan (*Baker 8355*).

This species is variable in size; specimens measure from 5.25 to 7.5 millimeters in length, but otherwise are identical.

Agrilus luzonicus Kerremans.

This species seems to be rather common and to have a wide distribution, as specimens were examined from the following localities: Mount Maquiling, Luzon (*Baker 8316, 8314, 8315, 8317*); Los Baños, Luzon (*Baker*); Tacloban, Leyte (*Baker*); Davao, Mindanao (*Baker*).

The specimens are uniform in size but vary in color from greenish blue to bright brassy green.

Agrilus nigrocinctus Saunders.

Specimens of this species were examined from the following localities: One male from Davao, Mindanao (*Baker 8368*) and a female from Baguio, Benguet Province, Luzon (*Baker*).

Agrilus inquinatus Saunders.

Material of this species was examined from the following localities in Mindanao: One male and one female from Davao (*Baker 8324, 8361*); two females from Zamboanga (*Baker 8321*); a male from Butuan (*Baker*).

Agrilus subspinosus sp. nov.

Male.—Form elongate, rather slender, head and sides of pronotum aëneous, disk of pronotum dark olive green, with a purplish tinge; elytra aëneous, becoming purpureous toward apex; each elytron ornate with an inconspicuous wide band of short white pubescence, reaching from the basal depressions along suture to just beyond the middle, then obliquely backward toward lateral margin, but not quite reaching it.

Antennæ aëneous, becoming black toward tip, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front convex, sides slightly narrowed toward clypeus, broadly and rather deeply impressed on vertex, less deeply on occiput; surface finely rugose, with the intervals sparsely punctate and very finely granulate, with a row of white hairs along lateral margin and a few sparsely placed ones behind clypeus. Clypeus slightly wider than long, with the front margin truncate. Pronotum one-third wider than long, slightly narrowed at base; sides nearly straight anteriorly, slightly arcuate behind middle and narrowly explanate; lateral margin strongly sinuate when viewed laterally; behind angles rectangular, with a well-defined arcuate carina, the carina extending to lateral margin near middle; disk convex, with a broad lateral depression and the median line with two vague depressions, the posterior the larger; surface finely, densely, irregularly strigose, the intervals between the ridges densely and coarsely punctate, each puncture with a short, erect, inconspicuous hair. Scutellum transversely carinate. Elytra distinctly sinuate behind the humeri, with a very feeble postmedian dilatation, then strongly narrowed to apices; sides of abdomen exposed above; each elytron emarginate at tip, the sutural angle produced into a long acute spine which is feebly serrate on the inner side, the lateral margin feebly serrate and extending into a very minute spine; disk rather flat, without distinct costæ, the sutural edge rather strongly elevated at apical third; humeri moderately prominent, not carinate; basal depressions moderately deep; surface shining, coarsely punctate-granulate, becoming smoother and feebly imbricate near apex, sparsely clothed with short, inconspicuous hairs and ornamented as above. Body beneath aëneous; prosternum densely and very finely punctate along the middle, clothed with fine, suberect, silky pubescence, sides coarsely punctate and scabrous; prosternal lobe broad, deeply and arcuately emarginate at middle; intercoxal process broad, sides feebly broadened behind coxæ, apex truncate and biemarginate; propleura coarsely punctate and slightly strigose, sparsely pubescent; metasternum roughly scabrous, somewhat strigose and pubescent. Abdomen densely punctate at sides, especially near base, more sparsely along median line; first ventral segment slightly depressed at middle, second with a narrow longitudinal smooth line extending to middle; last ventral broadly concave, with a feeble longitudinal

carina extending from apex to about the middle, obtusely rounded at tip; vertical portions without conspicuous pubescent areas; pygidium finely punctate, subacute at apex, the carina well marked but not projecting. Hind tarsi two-thirds as long as the tibiæ, first joint just about equal in length to the four following joints united; anterior and middle tibiæ with a distinct mucro at the inner apex, posterior tibiæ simple; claws similar on all the tarsi, divaricate, broadly toothed, the lower portion not incurved.

Length, 7.25 millimeters; width, 1.8.

Female.—Differs from the male as follows: Head darker in color; prosternum densely and roughly scabrous over entire surface, without distinct pubescence; first ventral segment convex, uniformly punctate and pubescent; last ventral convex, without longitudinal carina, obtusely rounded at apex; tibiæ not mucronate.

Described from two specimens. The type is a male from Davao, Mindanao (*Baker*); the allotype is a female from Mount Maquiling, Luzon (*Baker*).

Agrilus banahaoensis sp. nov.

Male.—Form elongate, subcylindrical, front of head aëneous, occiput of head and pronotum cyaneous, elytra dark blue, becoming violaceous posteriorly.

Antennæ aëneous, reaching a little beyond the middle of pronotum, serrate from the fourth joint. Head with the front flat, the sides nearly parallel; occiput rather deeply and broadly impressed, with a feeble broad impression on the front; surface strongly, transversely strigose, the intervals sparsely punctate, finely granulate and very sparsely clothed with a few inconspicuous hairs. Clypeus wider than long, with the front margin truncate. Pronotum one-third wider than long, slightly narrower at base than apex; sides slightly sinuate, lateral margin strongly sinuous when viewed laterally; hind angles rectangular, with a sharply defined, arcuate carina, the carina ending abruptly near lateral margin at basal third, disk moderately convex, a moderately deep, oblique, lateral depression and a vague anterior and posterior depression on the median line; surface finely, densely, and irregularly strigose, the intervals between the strigæ densely and coarsely punctate, each puncture with a short, erect, inconspicuous hair. Scutellum transversely carinate. Elytra with a slight posthumeral sinuation, behind

which there is a slight dilatation, then strongly narrowed to apices, which are bispinose, the inner spine long, acute, and on a line with the middle of the elytron, lateral margin smooth, extending into a sharp spine which is shorter than the inner one; sides of abdomen exposed above; disk slightly flattened, without distinct costæ, the sutural edge strongly elevated behind the middle; humeri prominent, with a very minute carina at base; basal depressions moderately deep; surface shining, rather finely and densely, imbricately granulate, smoother near apex, rather densely clothed with short, semierect hairs, which do not conceal the surface sculpture. Body beneath plumbeous, with the legs of a more greenish color; prosternum densely, roughly scabrous and sparsely, finely pubescent; prosternal lobe broadly rounded and deeply, arcuately emarginate in front; intercoxal process broad, sides parallel to behind coxæ, then abruptly narrowed to apex, which is acute; propleura finely punctate and sparsely pubescent; metasternum at sides densely and rather coarsely punctate, smooth along the middle and rather densely pubescent. Abdomen finely punctate at middle, more densely at sides, sparsely clothed with distinct white hairs; first ventral segment feebly flattened and slightly more densely punctured and pubescent; last ventral obtusely rounded at apex; vertical portions of the segments not conspicuously pubescent; pygidium finely punctate, pubescent at apex, the carina well marked, but not projecting. Hind tarsi nearly half as long as the tibiæ, first joint about equal in length to the four following joints united; front tibiæ feebly arcuate; middle and posterior tibiæ straight, not mucronate at tip; claws similar on all the tarsi, divaricate, broadly toothed at base, the lower portion not incurved.

Length, 8 millimeters, width, 2.1.

Described from a single male specimen from Mount Banahao, Luzon (*Baker*).

Agrilus maquilingensis sp. nov.

Female.—Form elongate, rather slender; entirely aëneous.

Antennæ aëneous, reaching a little beyond the middle of pronotum, serrate from the fourth joint. Head with the front rather convex and slightly gibbose at the sides on vertex; sides nearly parallel, abruptly and deeply impressed on the vertex, becoming less distinct on the occiput; surface finely rugose, with the intervals sparsely punctate and finely, densely granulate, the rugæ becoming more distinct and longitudinal on the occiput, sparsely

clothed with a few long yellow hairs behind the clypeus. Clypeus wider than long, with the front margin nearly truncate. Pronotum one-third wider than long, distinctly narrower at base than apex; sides nearly straight in front, sinuate posteriorly; lateral margin very nearly straight when viewed laterally; hind angles rectangular, with a well-defined, slightly arcuate carina, the carina extending to lateral margin near middle; disk strongly convex, with a feeble lateral depression and another similar one in front of scutellum; surface coarsely, closely, transversely strigose, the intervals between the strigæ finely and sparsely punctate. Scutellum transversely carinate. Elytra strongly sinuate behind the humeri, with the postmedian dilatation nearly entirely concealing the sides of abdomen from above, strongly narrowed to the apices; each elytron rather feebly, arcuately emarginate at tip, the angles produced into short spines, which are equal in length, outer edge of elytron near apex smooth; disk rather flat, without distinct costæ, sutural edge gradually elevated from the basal fourth, becoming quite distinct behind the middle; humeri rather prominent, not carinate; basal depressions rather feeble; surface subopaque, finely, densely granulate-scabrous, and sparsely clothed with short, white, recumbent hairs, which do not conceal the surface sculpture. Body beneath aëneous, more shining than above; prosternum densely, roughly scabrous, without pubescence; prosternal lobe acutely and rather deeply emarginate at middle; intercoxal process broad, sides nearly parallel, abruptly narrowed to apex, which is acute; propleura coarsely punctate, slightly strigose, not pubescent; metasternum closely punctate and strongly reticulate, without conspicuous pubescence. Abdomen finely and rather closely punctate, distinctly strigose at base, with fine punctures along the edge of the strigæ, nearly glabrous; first ventral segment convex, not impressed nor pubescent; last ventral feebly truncate at apex, with few feeble asperities posteriorly; vertical portions not conspicuously pubescent; pygidium punctate, subacute at apex, the carina well marked, but not projecting at tip. Hind tarsi a little more than half as long as tibiæ, first joint distinctly longer than the four following joints united; all tibiæ nearly straight, not mucronate at tip; claws similar on all the tarsi, divaricate, broadly toothed at base, the lower portion not incurved.

Length, 6 millimeters; width, 1.8.

Described from a unique female from Mount Maquiling, Luzon (*Baker*).

Agrilus occipitalis Eschscholtz.

This seems to be the commonest species of the genus in the Philippines, and all the specimens examined are quite uniform in size and coloration. Material has been examined from the following localities in Mindanao: Davao (*Baker 8358, 8359*); Zamboanga (*Baker 8347*); Dapitan (*Baker 8301*); Butuan (*Baker 8302*). Specimens from Luzon are from Malinao (*Baker 8304*) and Mount Maquiling (*Baker*). Material in the United States National Museum collection without definite locality is labeled "Bur. Agri., P. I., Acc. Nos. 183, 242, 252, 1484, 2269 collected by B. Arce and C. R. Jones." The Bureau of Agriculture reports localities and collectors for these numbers as follows: Manila (*Arce 183, 1484, Jones 252*); Santo Tomas, Batangas Province, Luzon (*Jones 242*); Diklom, Bukidnon, Mindanao (*John T. Zimmer 2269*).

Agrilus albocinctus sp. nov.

Form short, rather robust, front of head and beneath aëneous, posterior part of head, pronotum, and elytra greenish blue, with a strong violaceous tinge.

Antennæ dark, with the basal joints aëneous, reaching to basal fourth of pronotum, and serrate from the fourth joint. Head with the front strongly convex, sides strongly expanded at vertex, then narrowed both posteriorly and toward clypeus, broadly and feebly impressed on vertex and occiput; surface nearly smooth, shining, with a few indistinct punctures and clothed with a row of sparsely placed, short white hairs along the lateral margin. Clypeus with the front margin truncate, slightly wider than long. Pronotum two-thirds wider than long, not narrower at base than apex, sides nearly straight, slightly sinuate near hind angles, lateral margin nearly straight; hind angles rectangular, with a feebly defined straight carina, the carina extending to near lateral margin at middle; disk convex, with a wide, oblique, lateral depression extending along the basal fourth; surface finely and rather distantly striate, the intervals smooth and shining. Scutellum transversely carinate. Elytra slightly sinuate behind the humeri, slightly broadened behind middle, nearly entirely concealing the sides of the abdomen from above, then strongly, obliquely narrowed to the apices, which are separately rounded and rather strongly serrulate; disk convex, without distinct costæ, sutural edge feebly elevated near apex; humeri moderate, without carina; basal depressions rather feeble but more distinct than in *A. subpubescens;* surface shining,

coarsely, imbricately granulate, becoming smoother near apex, sparsely clothed with short inconspicuous hairs and each elytron with a transverse band of white pubescence at the apical third and a similar band at tip. Body beneath dark aëneous; prosternum sparsely and coarsely rugose, finely granulate between the rugæ and sparsely pubescent; prosternal lobe broad, very broadly rounded and fully truncate in front; intercoxal process broad, sides parallel, with the edge strongly, abruptly elevated along the coxæ, abruptly narrowed at tip; propleura punctate, feebly reticulate and sparsely pubescent; metasternum strongly, transversely strigose, with fine punctures along the edge of the strigæ, sparsely pubescent. Abdomen sparsely and coarsely strigose at base, becoming more densely, finely strigose and punctate at the sides, sparsely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last ventral broadly and feebly, transversely concave, the apex acutely, but not deeply emarginate at middle; vertical portions not conspicuously pubescent; pygidium punctate and carinate at middle, the carina not projecting at apex. Hind tarsi very short, one-fourth as long as the tibiæ, first joint slightly longer than the second; all of the tibiæ nearly straight, without a distinct mucro; hind femora not as robust as in *A. subpubescens;* claws similar on all tarsi, strongly cleft, the lower portions incurved, but with the points distant.

Length, 5 millimeters; width, 1,7.

Described from three specimens, which are probably all males. The type is from Davao, Mindanao (*Baker 8313*). One paratype from the same locality and another from Zamboanga, Mindanao (*Baker*).

This species is closely allied to *A. subpubescens* but can be easily distinguished from that species by the white pubescent band on the elytra, the broadly rounded prosternal lobe, and by having the sides of the intercoxal process abruptly elevated along the coxæ.

Agrilus subpubescens sp. nov.

Form short, rather robust, color entirely greenish blue, some examples with a purplish tinge on the elytra.

Antennæ cupreous, with the basal joints more or less aëneous, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front nearly flat, widest at clypeus, then gradually narrowed posteriorly; vertex and occiput slightly impressed; surface strongly rugose, the rugæ becoming less distinct

anteriorly, intervals sparsely, coarsely punctate, with a patch of white pubescence along lateral margin behind clypeus. Clypeus slightly wider than long, front margin truncate, with a sharp tooth at each anterior angle. Pronotum twice as wide as long, not narrower at base than apex; sides strongly arcuate in front, obliquely narrowed behind; lateral margin straight; hind angles rectangular, without trace of a carina; disk moderately convex, without lateral or median depressions; surface coarsely, closely, transversely strigose, the intervals between the strigæ sparsely and finely punctate. Scutellum wide, transversely carinate. Elytra with a slight posthumeral sinuation, behind which there is a slight dilatation, then strongly, obliquely narrowed to the apices, which are conjointly rounded and feebly serrulate, sides of abdomen exposed above; disk convex, without distinct costæ, the sutural edge elevated at apical third; humeri moderately prominent, not carinate; basal depressions almost obliterated; surface shining, coarsely and closely, imbricately granulate, coarser near the base, sparsely clothed with short, inconspicuous, recumbent hairs which do not conceal the surface sculpture. Body beneath usually more greenish than above; prosternum coarsely and densely scabrous, opaque and sparsely pubescent; prosternal lobe broad, deeply and rather acutely emarginate at middle; intercoxal process broad, sides parallel, abruptly narrowed at apex; propleura coarsely punctate, slightly strigose and sparsely pubescent; metasternum strigose and with fine punctures along the edge of the strigæ. Abdomen sparsely and finely punctate, becoming feebly strigose at side, sparsely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last ventral truncate and feebly emarginate at apex; vertical portions not conspicuously pubescent; pygidium punctate, feebly carinate, the carina not projecting at apex. Hind tarsi very short, one-fourth as long as the tibiæ, first joint about equal in length to the two following joints united; anterior tibiæ feebly arcuate, the middle and posterior tibiæ simple, not mucronate; posterior femora very robust, resembling species of the chrysomelid genus *Altica;* claws similar on all tarsi, strongly cleft, the lower portion incurved, but with the tips quite distant.

Length, 5.5 millimeters; width, 1.9.

Described from four specimens, probably all males. The type is from Davao, Mindanao (*Baker 8366*). Paratypes are from Davao and Zamboanga, Mindanao; and from Malinao, Tayabas Province, Luzon; all specimens collected by C. F. Baker.

Agrilus zamboangensis sp. nov.

Male.—Form very short, rather robust, head and pronotum bright brassy green, elytra dark brown, with a distinct metallic luster.

Antennæ aëneous, reaching to basal fourth of pronotum, serrate from the fourth joint. Head with the front convex, sides nearly parallel to vertex, then slightly narrowed posteriorly; occiput slightly, longitudinally impressed; surface strongly rugose on vertex and occiput, with two smooth areas on the front, intervals strongly and rather densely punctate, with patches of long white pubescence along lateral margin and behind clypeus. Clypeus slightly wider than long, with the front margin truncate and with a sharp tooth at each anterior angle. Pronotum two-thirds wider than long, not narrower at base than apex; sides feebly arcuate in front, slightly sinuate posteriorly; lateral margin nearly straight; hind angles rectangular, with an indistinct, short, straight carina; disk convex, without lateral or median depressions; surface coarsely, closely, transversely strigose, the intervals between the ridges sparsely and finely punctate. Scutellum wide, transversely carinate. Elytra with a feeble posthumeral sinuation, scarcely dilated behind middle, then broadly, arcuately narrowed to apices, which are separately, acutely rounded and feebly serrulate; sides of abdomen entirely concealed from above; disk convex, without distinct costæ, sutural edge scarcely elevated; humeri moderately prominent, not carinate; basal depressions rather feeble; surface shining, coarsely imbricate, slightly rugose at sides and sparsely clothed with distinct, short, yellowish, recumbent hairs. Body beneath piceous, with a greenish tinge; prosternum roughly scabrous, sparsely pubescent; prosternal lobe broad, broadly, arcuately emarginate at middle, intercoxal process wide, sides parallel to behind coxæ, then abruptly narrowed to apex, which is rather obtuse; propleura coarsely, densely punctate and feebly reticulate, very sparsely pubescent; metasternum strigose and closely punctate. Abdomen finely strigose, with fine punctures along the edge of the strigæ, the strigæ coarser at base than at sides, sparsely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last ventral truncate and feebly emarginate at apex; pygidium punctate, with a feeble median carina, which does not project at tip. (Hind tarsi broken off.) Anterior tibiæ with an extremely feeble mucro at the tip; middle and posterior tibiæ simple; claws on front and

middle tarsi similar, strongly cleft, the lower portion feebly incurved but with the tips distant.

Length, 4 millimeters; width, 1.5.

Described from a single male from Zamboanga, Mindanao (*Baker*).

Agrilus inconstans sp. nov.

Male.—Form rather elongate and moderately robust, varying in color from bronzy to cupreous, except head, which is dull green.

Antennæ greenish, reaching to middle of pronotum, serrate from the fourth joint. Head with front convex, the sides slightly, arcuately emarginate between vertex and clypeus; occiput with scarcely any trace of longitudinal impression; surface densely, rather coarsely punctate and finely granulate, becoming rugose on the occiput; clothed with very short white hairs, becoming denser and longer toward clypeus. Clypeus wider than long, with the front margin broadly, arcuately emarginate. Pronotum one-half wider than long, distinctly narrowed at base; sides feebly arcuate, lateral margin straight; hind angles rectangular, without distinct carina; disk convex, without lateral or median depressions; surface coarsely, closely, transversely strigose, the intervals between the ridges finely and sparsely punctate. Scutellum transversely carinate. Elytra rather strongly sinuate behind the humeri, with a very feeble postmedian broadening, then strongly, obliquely narrowed to apices, which are separately rounded and finely serrulate; sides of abdomen widely exposed above; disk convex, without distinct costæ; sutural edge slightly elevated near apex; humeri moderate, not carinate; basal depressions moderately deep; surface subopaque, closely and rather finely, imbricately granulate, coarser near the base, sparsely clothed with short, white, recumbent hairs, in some specimens forming a broad inconspicuous vitta along the suture. Body beneath aëneous; prosternum densely and strongly scabrous, sparsely clothed with long silky pubescence; prosternal lobe broadly, arcuately rounded in front; intercoxal process not very broad, gradually narrowed from in front of coxæ to apex, which is rather acute; propleura finely punctate and feebly strigose, sparsely pubescent and farinaceous, metasternum at sides strongly strigose and densely punctate, rather densely pubescent and more or less farinaceous. Abdomen rather coarsely and densely punctate, becoming strigose on the sides of the first two

segments, rather densely clothed with short, recumbent, white pubescence; first ventral segment convex, the middle with a longitudinal series of long, semierect, silken hairs; last ventral feebly concave, with a series of longer hairs and distinct asperities posteriorly, feebly, arcuately emarginate at apex; vertical portions except the first and second densely clothed with white pubescence; pygidium punctate, with a median carina, which is not projecting at apex. Hind tarsi not quite one-half as long as the tibiæ, first joint about as long as the second and third joints united; anterior tibiæ feebly arcuate, with a very feeble mucro at tip; middle and posterior tibiæ simple; claws similar on all tarsi, strongly cleft, the lower portion incurved, with the point not quite touching that of the opposite side.

Length, 5.75 millimeters; width, 1.75.

Female.—Differs from the male in having the front of head cupreous, slightly less pubescent; first ventral segment without distinct, long, semierect hairs, and by having all the tibiæ simple.

Described from six specimens, one male and five females. The type, which is a male, is from Davao, Mindanao (*Baker 8325*); alloptype from the same locality (*Baker 8365*). Paratypes: One female from same locality as type; one female from Baguio, Benguet Province, Luzon; one female from Puerto Princesa, Palawan; and a female from Mount Maquiling, Luzon, all collected by C. F. Baker.

The female from Luzon has the front of head more convex and strongly, transversely rugose, becoming concentrically rugose on the vertex, and the front margin of prosternal lobe more squarely truncate than in the type.

Agrilus rotundipennis sp. nov.

Male.—Form elongate, subcylindrical, color uniformly dark blue, with a slight greenish tinge, each elytron with the tip and a round spot near suture at apical third of short white pubescence.

Antennæ brassy, reaching to middle of pronotum, serrate from the fourth joint. Head with the front nearly flat, sides slightly narrowed toward clypeus; vertex broadly and rather deeply impressed, the impression becoming nearly obliterated near clypeus; surface sparsely and rather coarsely punctate, becoming concentrically rugose on vertex, intervals smooth and shining, nearly glabrous. Clypeus slightly wider than long, with the front margin broadly, arcuately emarginate. Pronotum nearly one-half wider than long, not narrower at base than apex; sides feebly arcuate in front, slightly sinuate behind the middle,

lateral margin strongly sinuate when viewed laterally; hind angles rectangular, without trace of carina; disk convex, the median line with a moderately deep anterior and posterior depression, and a deep oblique depression at side connecting with the posterior depression at middle; surface finely and rather distantly, irregularly striate, the intervals smooth and shining. Scutellum transversely carinate. Elytra feebly sinuate behind humeri, scarcely dilated behind the middle, then strongly narrowed to apices, which are separately, very broadly rounded and strongly serrulate; sides of abdomen widely exposed above; disk feebly flattened, without costæ, sutural edge elevated behind the middle; humeri moderately prominent, not carinate; basal depressions rather deep; surface shining, coarsely rugose and rather densely punctate, the rugæ becoming finer toward apex, sparsely clothed with short, inconspicuous hairs and ornamented as above. Body beneath similar to that above; prosternum sparsely rugose and coarsely punctate, sparsely pubescent; prosternal lobe broad, truncate in front; intercoxal process broad, sides parallel to behind coxæ, then abruptly narrowed to apex, which is rather acute; propleura finely reticulate and sparsely pubescent; metasternum coarsely punctate-strigose, along the middle much smoother, the sides rather densely pubescent. Abdomen sparsely strigose, with fine punctures along the edge of the strigæ, nearly glabrous; first ventral segment convex, not impressed nor pubescent; last ventral obtusely rounded at apex; vertical portion of first segment densely pubescent on the posterior half; pygidium without projecting carina at apex. Hind tarsi about one-third as long as tibiæ, first joint equal in length to the four following joints united; anterior tibiæ feebly mucronate, the middle and posterior ones simple; claws similar on all tarsi, strongly cleft, the lower portion feebly incurved, but with tips quite distant.

Length, 8 millimeters; width, 2.5.

Described from a male specimen in the United States National Museum collection labeled "Acc. No. 1666, Bur. Agri., P. I., collected by C. R. Jones," without any definite locality given. The Bureau of Agriculture reports that this specimen was collected at Lamao, Bataan Province, Luzon.

This species is closely allied to *A. monticola* Kerrem.[5] I have not seen any specimens of Kerremans's species, but in the description he states that the hind angles of the pronotum are carinate, while in *A. rotundipennis* there is no trace of a carina.

[5] *Agrilus monticola* Kerrem. || = *Agrilus oreophilus* Fisher.

Agrilus bakeri Kerremans.

This species is represented in the collection by a single specimen from Baguio, Benguet Province, Luzon (*Baker*).

Agrilus subviridis sp. nov.

Male.—Form a little shorter and more robust than *A. rotundipennis*, of a uniform bluish green color, front of head green, becoming bluish on vertex and occiput.

Antennæ slightly cupreous, reaching just a little beyond front angles of pronotum, serrate from the fourth joint. Head with the front nearly flat, the sides strongly narrowed from vertex to clypeus; vertex broadly but not very deeply impressed, the impression becoming less distinct toward clypeus; surface sparsely and finely punctured, becoming finely, concentrically rugose on vertex, intervals smooth and shining, glabrous. Clypeus triangular, scarcely wider than long, with front margin broadly, arcuately emarginate. Pronotum nearly one-half wider than long, slightly narrower at base than apex, sides feebly arcuate, lateral margin slightly sinuous when viewed laterally, hind angles rectangular, without trace of carina; disk convex, a rather deep, oblique depression at the side nearly reaching median line, which is feebly, transversely impressed in front of scutellum; surface coarsely, closely, and irregularly strigose, intervals between strigæ sparsely and rather finely punctate. Scutellum transversely carinate. Elytra slightly sinuate behind humeri, a little dilated behind the middle, then strongly, obliquely narrowed to the apices which are separately, broadly rounded and strongly serrulate, sides of the abdomen feebly exposed above; disk slightly flattened without distinct costæ, sutural edge strongly elevated from middle to apex; humeri moderately prominent, not carinate; basal depressions large and moderately deep; surface rather shining, coarsely, transversely rugose, becoming smoother and feebly imbricate near apex, intervals sparsely punctate and glabrous. Body beneath aëneous; prosternum densely, coarsely rugose and sparsely clothed along median line with long, semierect, white pubescence; prosternal lobe broadly truncate in front; intercoxal process broad, sides parallel to behind coxæ, then narrowed to apex, which is acute; propleura coarsely and rather densely punctate, vaguely strigose, and feebly pubescent; metasternum densely and roughly, rugosely punctate, rather densely pubescent. Abdomen strongly, transversely strigose, with fine punctures along the edge of the strigæ, sparsely pubescent; first ventral segment

convex, not impressed nor conspicuously pubescent; last segment broadly concave, very densely, finely punctate, and densely clothed with long silky pubescence, apex broadly rounded; vertical portions of segments glabrous; pygidium without projecting carina. Hind tarsi not quite one-half as long as tibiæ; first joint nearly as long as the four following joints united; anterior tibiæ feebly arcuate, with a slight mucro at the inner apex, middle and posterior tibiæ simple; claws similar on all tarsi, strongly cleft, the lower portion incurved, with the point not quite touching that of the opposite side.

Length, 7 millimeters; width, 2.25.

Described from two specimens. The type from Davao, Mindanao (*Baker 8300*) ; a paratype from Mount Maquiling, Luzon (*Baker*).

Agrilus semipubescens sp. nov.

Form elongate, subcylindrical, color uniformly olivaceous.

Antennæ piceous, with the basal joints greenish, reaching to the middle of pronotum, serrate from the fourth joint. Head with the front nearly flat, sides nearly parallel from clypeus to vertex, then strongly narrowed posteriorly; vertex broadly, but not deeply, longitudinally impressed, the impression reaching to the middle of the front; surface densely and coarsely punctate, becoming slightly rugose on occiput, and nearly glabrous. Clypeus wider than long, with the front margin truncate. Pronotum one-third wider than long, slightly narrower at base than apex; sides feebly arcuate in front, sinuate behind the middle; lateral margin nearly straight when viewed laterally; hind angles rectangular, without a carina; disk convex, without a distinct lateral depression, on the median line two feeble depressions, the posterior the larger; surface coarsely, closely, transversely strigose, the intervals sparsely and finely punctate. Scutellum wide, strongly, transversely carinate. Elytra with a slight posthumeral sinuation, behind which is a slight dilation, then strongly narrowed to apices, which are separately, rather broadly rounded and strongly serrulate, sides of abdomen visible from above; disk rather convex, feebly, broadly concave along suture, without distinct costæ, sutural edge elevated behind the middle, humeri moderately developed, not carinate; basal depressions moderately deep; surface feebly shining, coarsely and densely, imbricately granulate, but smoother toward apex, rather densely clothed with short, semierect white hairs, which form a wide inconspicuous band along the suture. Body beneath

olivaceous, slightly darker than above; prosternum densely and coarsely scabrous; sparsely pubescent; prosternal lobe broadly but feebly emarginate; intercoxal process strongly expanded behind the coxæ, the apex broad, biemarginate, with a sharp tooth at middle; propleura with reticulate sculpture and sparsely pubescent; metasternum rather coarsely imbricate and feebly pubescent. Abdomen finely strigose-punctate, the strigæ coarser at base and along sides of first and second segments, sparsely pubescent; first ventral segment convex, not impressed nor pubescent; last ventral feebly concave, truncate and feebly emarginate at apex; vertical portions not conspicuously pubescent; pygidium punctate, carina along the middle, the carina not projecting at apex. Hind tarsi about one-half as long as tibiæ, first joint as long as the four following joints united; tibiæ simple, claws divaricate, broadly toothed at base.

Length, 6.5 millimeters; width, 1.75.

Described from a unique specimen which is probably a male, collected at Butuan, Mindanao (*Baker*).

Agrilus subvittatus sp. nov.

Male.—Form more robust than in *A. fulvovittatus*, color slightly more cupreous than in that species and with the vitta less distinct.

Antennæ piceous, reaching a little beyond middle of pronotum, serrate from the fourth joint. Head with the front nearly flat, sides roundly expanded at middle, then gradually narrowed posteriorly and toward clypeus; vertex slightly, longitudinally impressed; with a broad shallow impression behind the clypeus, which is slightly elevated; surface transversely rugose on front, becoming longitudinally rugose on vertex and occiput, intervals sparsely and coarsely punctate, with a few short white hairs behind clypeus. Clypeus wider than long, the front margin deeply, arcuately emarginate. Pronotum fully one-half wider than long, slightly narrower at base; sides slightly arcuate; lateral margin nearly straight when viewed laterally; hind angles rectangular, without trace of carina in either sex; disk moderately convex, the median line with a feeble, transverse, anterior and posterior depression and a shallow oblique depression at the side extending to the posterior median one; surface coarsely, closely, transversely strigose, the intervals between the ridges sparsely and finely punctate, from each puncture arises a short, inconspicuous hair. Scutellum wide, strongly, transversely carinate. Elytra sinuate behind humeri, scarcely dilated

behind the middle, then strongly narrowed to apices, which are separately, rather broadly rounded and strongly serrulate; sides of abdomen visible from above; disk rather convex, without distinct costæ; humeri moderately prominent, not carinate; basal depressions moderately deep; surface rather shining, strongly and densely, imbricately granulate, the granulation coarser than in *A. fulvovittatus*, becoming finer posteriorly, sparsely clothed with short, fine, semierect hairs and ornamented as above. Body beneath dark aëneous; prosternum coarsely and densely rugose, sparsely pubescent, without conspicuous pubescence at middle; prosternal lobe broadly rounded, with an acute emargination at middle; intercoxal process rather narrow, sides parallel to behind coxæ, then gradually narrowed to apex, which is acute; propleura rather densely punctate and pubescent; metasternum coarsely strigose-punctate and rather densely pubescent. Abdomen rather densely strigose-punctate, the strigæ becoming coarser at base and sides of first and second segments, sparsely clothed with rather long white pubescence; first ventral segment convex, with a distinct sharp tooth at middle posteriorly; last ventral feebly concave, apex acutely rounded, with a series of distinct asperities along the margin; vertical portions of segments not conspicuously pubescent; pygidium without projecting carina at apex. Hind tarsi not quite one-half as long as the tibiæ, first joint about equal in length to the four following joints united; anterior and middle tibiæ mucronate at the inner apical angles, posterior tibiæ simple; claws similar on all the tarsi, cleft near apex, forming a short, acute tooth; the lower portion is very feebly incurved in some specimens.

Length, 6.75 to 7.50 millimeters; width, 2 to 2.4.

Female.—Differs from the male in having the front of the head cupreous, pubescence shorter, only the anterior tibiæ with an extremely feeble mucro at tip, and without a tooth on the median part of the first abdominal segment.

Described from one male and three females. The type is from Davao, Mindanao (*Baker*). Three female paratypes; two from Zamboanga, Mindanao (*Baker 8346*), and one from Butuan, Mindanao (*Baker 8299*).

Agrilus fulvovittatus sp. nov.

Male.—Form elongate, rather slender, head and pronotum brassy green, elytra green with a purplish tinge, each elytron with a narrow vitta of golden pubescence reaching from the basal depression to apex.

Antennæ brassy, reaching to apical fourth of pronotum, serrate from the fourth joint. Head with the front convex, the sides roundly expanded at vertex, then slightly narrowed posteriorly and toward clypeus; vertex and occiput very feebly, longitudinally impressed; surface finely scabrous, becoming longitudinally rugose on occiput, intervals finely, densely granulate, nearly glabrous. Clypeus wider than long, with the front margin deeply, arcuately emarginate. Pronotum one-half wider than long, strongly narrowed at base; sides moderately arcuate in front, sinuate behind the middle; lateral margin nearly straight when viewed laterally; hind angles rectangular without any trace of a carina in either sex; disk moderately convex without depressions, either at middle or sides; surface coarsely, closely, transversely strigose, the intervals between the ridges sparsely and finely punctate. Scutellum strongly, transversely carinate. Elytra sinuate behind the humeri, scarcely dilated behind the middle, then strongly narrowed to apices, which are separately, acutely rounded and strongly serrulate; sides of abdomen exposed above; disk with a distinct costa extending from humeri to apex, the interval between this and the suture feebly concave; sutural edge slightly elevated from middle to apex; humeri not well developed, not carinate; basal depressions rather feeble; surface subopaque, finely and densely, imbricately granulate, smoother at apex, and ornamented as above. Body beneath brassy green; prosternum densely granulate, with a broad band of densely placed, suberect, white hairs along the middle; prosternal lobe broadly rounded and vaguely emarginate at middle; intercoxal process not very wide, gradually narrowed to behind coxæ, then abruptly narrowed to apex, which is acute; propleura moderately, closely punctate and sparsely pubescent; metasternum densely, imbricately granulate, sparsely and finely pubescent. Abdomen finely strigose-punctate, becoming granulate at sides of first segment, finely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last ventral obtusely rounded at apex; vertical portions of the segments rather densely pubescent; pygidium without a projecting carina at apex. Hind tarsi one-half as long as the tibiæ, first joint equal in length to the two following joints united; anterior tibiæ feebly arcuate, with a slight mucro at the inner apical angle; middle and posterior tibiæ simple; claws dissimilar, anterior ones almost truly bifid, cleft near apex, middle ones less so, and the posterior ones cleft near middle, forming a rather broad tooth, the lower portion not incurved.

Length, 5.25 to 6.75 millimeters; width, 1.3 to 1.8.

Described from five specimens, probably all males. The type is from Mount Maquiling, Luzon. Paratypes from Davao (*Baker 8323*), Iligan, and Butuan, Mindanao; all specimens collected by C. F. Baker.

Agrilus innotatus sp. nov.

Female.—Form elongate, slender, color uniformly plumbeous, with a slight purplish and greenish tinge, except the front of head which is cupreous.

Antennæ black, with the basal joints slightly greenish, reaching to the base of pronotum, serrate from the fourth joint. Head with the front convex, the sides gradually narrowed from clypeus to occiput; vertex very slightly impressed; surface very finely rugose, the rugæ becoming more longitudinal and distinct on the occiput, intervals very finely granulate, with a few moderately long white hairs along the eyes and in front of clypeus. Clypeus slightly wider than long, with the front margin broadly, arcuately emarginate. Pronotum nearly one-half wider than long, distinctly narrower at base than apex; sides very feebly arcuate and narrowly explanate; lateral margin strongly sinuate; anterior part of disk strongly convex, with a deep, broad, lateral depression extending along the base; hind angles rectangular, with a sharply defined, slightly arcuate carina, the carina reaching the lateral margin near the middle; surface rather finely and irregularly strigose, the intervals between the strigæ wide and rather densely punctate, becoming more densely punctate near posterior angles. Scutellum transversely carinate. Elytra narrowed from the base, with a very feeble postmedian dilatation, then strongly, obliquely narrowed to the apices, which are separately, obtusely rounded, and rather strongly serrulate, the teeth well separated, sides of the abdomen exposed; disk slightly flattened along suture, without distinct costæ, sutural edge elevated behind the middle, humeri moderate, not carinate; basal impressions moderately deep; surface subopaque, closely and rather finely, imbricately granulate, rather densely clothed with distinct, short, whitish, recumbent hairs, although not dense enough to obscure the surface sculpture. Body beneath piceous with a greenish metallic luster; prosternum coarsely and sparsely scabrous, very feebly pubescent; prosternal lobe broadly, arcuately rounded in front; intercoxal process rather narrow, sides parallel, abruptly narrowed to apex, which is obtuse; propleura finely punctate, sparsely pubes-

cent; metasternum rather finely punctate and sparsely pubescent. Abdomen rather finely strigose-punctate, more coarsely at the base, moderately pubescent; first ventral segment convex, not impressed nor more pubescent than rest of body; last ventral subtruncate at apex; vertical portions of segments sparsely pubescent; pygidium rather strongly carinate, the carina projecting and truncate at tip. Hind tarsi a little more than one-half as long as tibiæ; first joint fully as long as the four following joints united; tibiæ simple; claws divaricate, broadly toothed at base.

Length, 5.25 millimeters; width, 1.5.

Described from a unique female from Davao, Mindanao (*Baker*).

Agrilus aguinaldoi sp. nov.

Male.—Form elongate, parallel, head greenish blue, pronotum and base of elytra blue, with a strong violaceous tinge, balance of elytra purplish brown, becoming violaceous toward apex.

Antennæ piceous, with a metallic luster, reaching to middle of pronotum, serrate from the fourth joint. Head with the front strongly convex, the sides gradually narrowed from occiput to clypeus; widely and very deeply, longitudinally impressed from occiput to clypeus, with the impression suddenly expanded at the middle of the front; surface coarsely and rather densely punctured, becoming concentrically rugose on the occiput, intervals smooth, sparsely clothed with long white hairs on the anterior half, the hairs becoming finer and darker posteriorly. Clypeus nearly square, narrower at base, front margin truncate with an obtuse tooth at each anterior angle. Pronotum quadrate, nearly as long as wide, slightly narrower at base than apex, sides rather strongly arcuate from apex to base; lateral margin very strongly sinuate when viewed laterally; hind angles rectangular, carina not well defined and reaching the lateral margin at basal third; disk strongly convex, with a very deep, round, lateral depression, the median line with a feeble impression in front of middle and a broad, deeper one in front of scutellum; surface coarsely, closely, and irregularly strigose, the intervals between the strigæ deep and densely, coarsely punctate, from each puncture arises a short, erect, inconspicuous hair. Scutellum strongly, transversely carinate, the carina bisinuate. Elytra strongly sinuate behind the humeri, with a strong postmedian dilatation, entirely concealing the sides of the abdomen from above, from the postmedian dilation the sides are broadly,

arcuately narrowed to the apices, which are separately, broadly rounded and very strongly serrulate; disk slightly concave along the suture without distinct costæ, sutural edge rather strongly elevated from apical third to apex; humeri strongly developed, not carinate; basal depressions very deep, with the humeri well developed; surface subopaque, coarsely rugose, sparsely and rather strongly punctate, becoming somewhat smoother toward apex, rather densely clothed with moderately long, inconspicuous pubescence, except along the suture where the hairs are lighter and form an inconspicuous elongate vitta. Body beneath greenish blue; prosternum very coarsely and densely scabrous, sparsely clothed with semierect white pubescence; prosternal lobe rather narrow, truncate and vaguely emarginate in front; intercoxal process rather wide, sides parallel to behind coxæ, then gradually narrowed to apex, which is acute; propleura coarsely punctate, slightly strigose, and sparsely pubescent; metasternum very coarsely punctate-strigose, sparsely pubescent. Abdomen coarsely punctate-strigose, the sculpture becoming rapidly finer toward apex and sparsely pubescent; first ventral segment convex, not impressed nor pubescent; last ventral broadly rounded at apex; pygidium coarsely, sparsely punctate, with a well-defined median carina, which is not projecting at apex. Hind tarsi a little more than one-half as long as the tibiæ, first joint as long as the four following joints united; anterior and middle tibiæ with a slight mucro at the inner apex, the posterior ones simple, with the outer margin flattened and strongly sinuate; claws divaricate, cleft close to the apex.

Length, 11 millimeters; width, 2.6.

Described from a unique male from Malinao, Tayabas Province, Luzon (*Baker*).

Agrilus palawanensis sp. nov.

Female.—Form a little shorter than *A. bisignatus*, color and markings similar to that species with the exception of an additional postscutellar pubescent area.

Antennæ cupreous, reaching a little beyond middle of pronotum, serrate from the fourth joint. Head with the front flat, wider than in *A. bisignatus*, the sides nearly parallel; vertex slightly, longitudinally impressed; surface rather finely scabrous, becoming strongly, longitudinally rugose on occiput, sparsely and evenly clothed with long, recumbent white hairs. Clypeus fully twice as wide as long, with the front margin broadly, arcuately emarginate. Pronotum nearly twice as wide

as long, slightly narrower at base than apex; sides arcuate from apex to base; lateral margin nearly straight when viewed laterally; hind angles rectangular, with a well-defined sinuate carina, the carina reaching the lateral margin near the apical angles; disk convex, with a feeble, oblique lateral concavity, without median depressions; surface rather finely and irregularly strigose, near sides and posterior angles simply punctate, the intervals between the rugæ densely and rather coarsely punctate, sparsely clothed with short, recumbent white hairs. Scutellum wide, strongly, transversely carinate. Elytra scarcely sinuate behind the humeri, without distinct postmedian dilatation, strongly, obliquely narrowed to apices, which are separately, rather broadly rounded and strongly serrulate; sides of abdomen broadly exposed above, disk feebly flattened, becoming rather deeply concave along suture behind the middle, with distinct costæ, sutural edge strongly elevated from apical third to tips, humeri moderate, not carinate; basal depressions moderately deep, surface shining, finely and very densely, imbricately granulate and rather densely clothed with short, distinct, white and yellow, recumbent hairs and ornamented as above. Body beneath aëneous, with a cupreous tinge; prosternum coarsely and densely scabrous, sparsely pubescent; prosternal lobe broadly rounded in front; intercoxal process rather narrow, sides parallel; squarely truncate at apex, with an acute tooth at middle; propleura densely, finely punctate and sparsely pubescent; metasternum at sides densely punctate. Abdomen finely, densely punctate-strigose, and moderately clothed with very short white pubescence; first ventral segment convex, not impressed nor conspicuously pubescent; last segment broadly concave and subtruncate at apex; vertical portions of the segments sparsely and evenly pubescent; pygidium without projecting carina. Hind tarsi one-half as long as tibiæ, first joint about equal in length to the two following joints united; tibiæ straight; claws divaricate, cleft at middle, forming an acute tooth, the lower portion not incurved.

Length, 6.5 millimeters; width, 2.

Described from a unique female from Puerto Princesa, Palawan (*Baker*).

This species superficially resembles *A. bisignatus*, but can be distinguished from that species by the following characters: Form much shorter, tips of the elytron more rounded, prosternal lobe broadly rounded, and by having the intercoxal process

squarely truncate at apex with an acute tooth at middle, while in *A. bisignatus* it is arcuately rounded at apex.

Agrilus bisignatus sp. nov.

Female.—Form elongate, rather robust, color uniform cupreous, each elytron with a small spot of pale yellowish pubescence near suture at apical third.

Antennæ brassy, with the other joints piceous, reaching a little beyond middle of pronotum, serrate from the fourth joint. Head with the front flat, sides nearly parallel; vertex very slightly impressed; surface strongly scabrous, strongly, longitudinally rugose on occiput, nearly glabrous. Clypeus about twice as wide as long, with the front margin broadly, arcuately emarginate. Pronotum one-half wider than long, narrower at base than apex; sides nearly straight to about basal third, then gradually narrowed to posterior angles; lateral margin strongly sinuate; hind angles rectangular, with a sharply defined sinuate carina, the carina reaching nearly to the apical angles; disk moderately convex, a moderately deep, oblique, lateral depression and on the median line two broad feeble depressions, the posterior one larger; surface rather finely, closely, and irregularly strigose, the depressions coarsely and densely punctate, feebly pubescent at sides and on median line. Scutellum wide, strongly, transversely carinate, the carina feebly sinuate. Elytra narrowed from the base, with a very feeble postmedian dilatation, then strongly, obliquely narrowed to the apices, which are separately, arcuately rounded and very strongly serrulate, sides of abdomen visible from above; disk feebly flattened, without distinct costa, sutural edge strongly elevated from the middle to apex; humeri moderately developed, not carinate; basal depressions rather deep; surface shining, finely and very densely, imbricately granulate, sparsely clothed with short, rather distinct, yellowish, recumbent hairs, and ornamented as above. Body beneath aëneous; prosternum coarsely and densely scabrous, sparsely pubescent; prosternal lobe broadly rounded in front, with a rather acute emargination at middle; intercoxal process rather broad, sides parallel to behind coxæ, then arcuately rounded to apex, which is obtuse; propleura coarsely punctate, slightly strigose, feebly pubescent; metasternum densely punctate-strigose and sparsely pubescent. Abdomen coarsely punctate-strigose at base, more densely and finely at sides and toward apex; first ventral convex, not impressed nor conspicuously pubescent; last segment rather acutely rounded and feebly

emarginate at apex, with a few sparsely placed asperities along the apical margin; vertical portions of the segments evenly pubescent; pygidium without projecting carina. Hind tarsi about one-half as long as the tibiæ, first joint fully as long as the four following joints united; anterior tibiæ feebly arcuate, the middle and posterior ones straight; claws divaricate, cleft at middle, forming an acute tooth, the lower portion not incurved.

Length, 7.5 millimeters; width, 2.25.

Described from a single female from Butuan, Mindanao (*Baker*).

Agrilus tayabensis sp. nov.

Male.—Form elongate, slender; color olivaceous bronze, with the head dark green.

Antennæ brassy, with the outer six or seven joints cupreous, densely and finely granulate, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front slightly convex, the sides nearly parallel to vertex, then slightly narrowed posteriorly; vertex slightly, longitudinally impressed; surface coarsely and very densely punctate, more rugose on the occiput and densely clothed in front of clypeus with long white pubescence. Clypeus slightly wider than long, with the front margin truncate. Pronotum nearly one-half wider than long, strongly narrowed toward the base, slightly arcuate in front, sinuate behind the middle; lateral sides nearly straight when viewed laterally; hind angles rectangular, with a sharply defined, strongly arcuate carina, the carina reaching lateral margin at the middle; disk moderately convex, with a broad, vague, lateral concavity and a faint antescutellar depression; surface rather finely, closely, transversely strigose, the intervals finely punctate. Scutellum strongly, transversely carinate. Elytra feebly sinuate behind the humeri, with scarcely any postmedian dilatation, then obliquely narrowed to the apices, which are separately, obtusely rounded and rather finely serrulate, sides of abdomen broadly exposed above; disk flattened, without distinct costæ, sutural edge feebly elevated near apex, humeri moderate, not carinate; basal depressions rather deep; surface shining, finely and densely, imbricately granulate, sparsely clothed with short, yellow, recumbent hairs, forming a broad inconspicuous vitta along the suture. Body beneath olivaceous bronze; prosternum sparsely granulate anteriorly, between the coxæ rugose, nearly glabrous; prosternal lobe broadly rounded, with a small acute emargination at middle; inter-

coxal process rather narrow, sides parallel to behind coxæ, then abruptly narrowed to apex, which is acute; propleura coarsely, sparsely punctate; metasternum at middle with a narrow, elongate, smooth area, sides finely, densely punctate and feebly pubescent. Abdomen transversely, finely strigose, with fine punctures along the edge of the strigæ, smoother toward apex, vaguely pubescent; first ventral segment with a short, transverse, inconspicuous elevation at middle along posterior margin; last segment feebly concave, with a series of asperities at middle near apex, the tip obtusely rounded; vertical portions of the segments sparsely punctate and glabrous; pygidium coarsely, sparsely punctate, with a median carina, but not projecting at apex. Hind tarsi about three-fourths as long as tibiæ, first joint fully as long as the four following joints united; anterior and middle tibiæ mucronate at apex, posterior one simple; claws divaricate, cleft close to apex, forming a sharp tooth, the lower portion not incurved.

Length, 5.2 millimeters; width, 1.9.

Female.—Differs from the male in having the front of head cupreous, less coarsely punctate, more finely granulate, and not so conspicuously pubescent in front of scutellum; basal half of elytra distinctly, transversely strigose; prosternal lobe broadly rounded; intercoxal process with the sides feebly elevated; abdomen less densely punctate, the first ventral segment simple, last segment convex, acute at apex, with a series of long asperities at the tip; tibiæ simple; and by having the claws broadly toothed at middle.

Described from two specimens. The type is a male from Malinao, Tayabas Province, Luzon (*Baker*); the allotype is from Baguio, Benguet Province, Luzon (*Baker*).

Agrilus dapitanensis sp. nov.

Female.—Form small, very slender; color piceous, head and legs greenish.

Antennæ slightly brassy, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front convex, the sides gradually narrowed from occiput to clypeus; vertex slightly, longitudinally impressed; surface sparsely and very finely punctured, the intervals dull, finely and densely granulate, sparsely clothed with long pale yellow hairs in front of clypeus. Clypeus narrow, triangular, with the front margin truncate. Pronotum one-third wider than long, narrower at base than apex, sides strongly arcuate in front, sinuate behind middle,

rather broadly explanate; lateral margin feebly sinuate when viewed from the side; hind angles rectangular, with a sharply defined, strongly angulate carina, the carina reaching lateral margin near apical third; disk strongly convex anteriorly, with a broad, rather deep, oblique, lateral depression extending along the base, the depression slightly deeper in front of scutellum; surface comparatively smooth, with a few indistinct strigæ and sparsely clothed with inconspicuous recumbent hairs. Scutellum transversely carinate. Elytra gradually narrowed to middle, with a feeble postmedian dilatation, then obliquely narrowed to apices, which are separately, obtusely rounded and finely serrulate, sides of abdomen nearly concealed from above; disk convex, with distinct costæ; sutural edge feebly elevated near apex, with a sharply elevated carina extending from humeri to middle, basal depressions almost obliterated; surface opaque, finely and densely, imbricately granulate, sparsely clothed with rather long recumbent pubescence. Body beneath piceous; prosternum densely scabrous, not pubescent; prosternal lobe broadly rounded in front; intercoxal process narrow, sides parallel to behind coxæ, then obtusely rounded; propleura finely reticulate; metasternum finely strigose. Abdomen sparsely punctate-strigose; first ventral segment convex, not impressed or pubescent; last segment obtusely rounded at apex; pygidium without projecting carina. Hind tarsi about one-half as long as the tibiæ, the first joint equal in length to the four following joints united; tibiæ simple; claws of anterior tarsi cleft at apex; (middle claws broken off); posterior claws cleft near base forming a short, acute tooth.

Length, 3.3 millimeters; width, 1.

Described from a single female from Dapitan, Mindanao (*Baker*).

Agrilus philippinensis sp. nov.

Male.—Form elongate, rather slender, color olivaceous bronze, head dull green, each elytron with a transverse dark band at apical third.

Antennæ brassy, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front slightly convex, the sides nearly parallel, slightly arcuate at middle of front; vertex very slightly, longitudinally impressed; surface sparsely and rather finely punctate, becoming slightly rugose on the occiput, intervals dull, finely and very densely granulate, sparsely clothed with long white hairs along the eyes and in front of

clypeus. Clypeus slightly wider than long, with the front margin nearly truncate. Pronotum nearly one-half wider than long, distinctly narrower at base than apex; sides strongly arcuate anteriorly, sinuate behind middle; lateral margin very nearly straight; hind angles sharply rectangular, with a sharply defined strongly arcuate carina, the carina reaching the lateral margin at the middle; disk convex, the median line with a vague anterior and posterior depression and with a vague, narrow, oblique, lateral depression; surface rather coarsely, closely, transversely strigose, the intervals rather densely and coarsely punctate. Scutellum not very wide, sharply, transversely carinate. Elytra gradually narrowed to middle, with a feeble postmedian dilatation, then strongly, obliquely narrowed to apices, which are separately, rather acutely rounded and finely serrulate, sides of abdomen visible from above; disk slightly concave along the suture, the concavity slightly wider at middle, without distinct costæ; sutural edge feebly elevated behind middle; humeri feeble, not carinate; basal depression rather feeble; surface shining, finely and densely, imbricately granulate, rather densely clothed with distinct, short, whitish, recumbent hairs, except for a denuded transverse dark band at the apical third. Body beneath olivaceous bronze; prosternum densely and rather finely scabrous, feebly pubescent; prosternal lobe broadly rounded, with a deep semicircular emargination at the middle, angles of the emargination very acute; intercoxal process broad, sides expanded behind coxæ, apex truncate, with a sharp tooth at the middle and the lateral angles very acute and incurved; propleura coarsely punctate, slightly strigose, and feebly pubescent; metasternum densely and finely rugose. Abdomen finely, densely punctate-strigose, vaguely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last segment subtruncate and feebly emarginate at apex; vertical portions of the segments glabrous; pygidium punctate, median carina well marked, but not projecting. Hind tarsi three-fourths as long as tibiæ, the first joint fully as long as the four following joints united; anterior and middle tibiæ mucronate at the inner apex, the posterior simple; claws of anterior and middle tarsi cleft at apex, the hind claws broadly toothed.

Length, 5 to 6.25 millimeters; width, 1.3 to 1.75.

Female.—Differs from the male in having the front of head cupreous, more densely punctate and transversely rugose, prosternal lobe less deeply emarginate, tibiæ simple, and the claws on all feet cleft at middle forming a broad tooth.

Described from three males and three females. The type is a male from Davao, Mindanao (*Baker 8364*); allotype from the same locality (*Baker 8362*). One male paratype (*Baker 8363*), two females and one male paratype without numbers, all from the type locality and collected by Baker. There is also a male from Mount Maquiling, Luzon (*Baker*).

The specimen from Mount Maquiling has the carina at posterior angles of pronotum longer, reaching to near the apical angles and strongly angulate at the middle, the median depression a little deeper, the rugæ broader, the intervals broad and not as coarsely punctate, sparsely clothed with short, inconspicuous, white hairs, which are a little more conspicuous on the median line; sides of elytra rather strongly sinuate behind humeri, basal depression deep, surface smoother and the prosternal lobe less deeply emarginate than in the type.

Agrilus attenuatus sp. nov.

Male.—Form small, elongate, and rather slender, color olivaceous bronze, head green, disk of pronotum slightly purpureous.

Antennæ brassy, with the outer joints cupreous, reaching nearly to posterior angles of pronotum, serrate from the fourth joint. Head with the front slightly convex, slightly narrower in front than behind, the sides slightly, arcuately emarginate from vertex to clypeus; vertex slightly, longitudinally impressed; surface dull, finely and very densely granulate, with a few sparsely placed indistinct punctures intermixed, becoming less granulate and finely rugose in front of clypeus and on occiput, sparsely clothed along eyes and in front of clypeus with long white hairs. Clypeus slightly wider than long, with the front margin nearly truncate. Pronotum one-fourth wider than long, distinctly narrower at base than apex, sides strongly arcuate; lateral margin feebly sinuate when viewed laterally; hind angles sharply rectangular, with a sharply defined arcuate carina, the carina reaching lateral margin near the apical angles; disk convex, median line with an indistinct anterior and posterior depression, without distinct lateral depressions; surface finely and transversely strigose, the intervals broad, feebly granulate, sparsely and feebly punctate. Scutellum not very wide, sharply, transversely carinate. Elytra slightly sinuate behind the humeri, a little broadened behind the middle, then obliquely narrowed to the apices, which are separately, obtusely rounded and finely serrulate; sides of abdomen slightly exposed; disk feebly flattened, without distinct costæ; sutural

edge elevated behind the middle; humeri feeble, not carinate; basal depressions moderately deep; surface feebly shining, finely and densely, imbricately granulate, becoming rugose at the sides, rather densely clothed with distinct, short, semierect whitish pubescence, the pubescence becoming indistinct along the lateral margin. Body beneath aëneous, more shining than above; prosternum finely, rugosely punctate, feebly pubescent; prosternal lobe rather acutely, but not deeply, emarginate at middle; intercostal process rather narrow, sides feebly broadened behind coxæ, then abruptly narrowed to apex, which is acute; propleura with reticulate sculpture; metasternum coarsely punctate-strigose at sides, smoother at the middle, with a short, feeble, elongate carina on the median line. Abdomen at base less coarsely punctate-strigose than side of metasternum, much smoother toward apex, vaguely pubescent; first ventral segment convex, not impressed or more pubescent than rest of surface; last segment obtusely rounded at apex; vertical portions of the segments not pubescent; pygidium coarsely punctate, carinate along median line, carina not projecting. Hind tarsi nearly as long as the tibiæ, the first joint equal in length to the four following joints united; anterior and middle tibiæ arcuate, with a mucro at the inner apex, the posterior simple; claws of anterior and middle tarsi cleft near apex, posterior claws cleft at middle forming a broad tooth.

Length, 4.5 millimeters; width, 1.1.

Female.—Differs from the male in having the front of head cupreous, prosternal lobe subtruncate at middle in front, prosternum slightly smoother, metasternum without median carina, tibiæ simple, and the claws on all the feet cleft at the middle forming a broad tooth.

Described from three males and one female. The type, which is a male, is from Butuan, Mindanao (*Baker 8308*); allotype from the same locality without any number. Also two males, one from Dapitan, Mindanao, and the other from Baguio, Benguet Province, Luzon (*Baker*).

The specimen from Baguio is not quite typical and differs from the type as follows: Pronotum entirely olivaceous bronze, wider and more rectangular, base and apex nearly equal in width, sides nearly straight, the two median depressions more distinct and the strigæ coarser and closer; elytra smoother and not quite so densely pubescent; prosternal lobe more deeply emarginate at middle; metasternum without tooth on median line, and the claws more broadly toothed.

Agrilus manilensis sp. nov.

Male.—Form small, elongate, and rather slender, color olivaceous bronze, head and legs green.

Antennæ brassy, with the outer joints cupreous, reaching nearly to the posterior angles of pronotum, serrate from the fourth joint. Head with the front narrow and slightly convex, the sides strongly narrowed from occiput to clypeus; vertex and occiput broadly, longitudinally impressed, causing the sides to become slightly gibbose; surface dull, finely and very densely granulate, with a few sparsely placed indistinct punctures, finely, longitudinally rugose on occiput and densely clothed along eyes and behind clypeus with long yellowish pubescence, the pubescent areas not granulate but finely punctate; clypeus small, slightly wider than long, front margin nearly truncate. Pronotum one-half wider than long, slightly narrower at base than apex; sides slightly arcuate from apex to base; lateral margin nearly straight when viewed laterally; hind angles rectangular, with a well-defined, slightly arcuate carina, the carina reaching lateral margin at about the apical third; disk convex, with a moderately deep median depression divided into two parts, without distinct lateral depression; surface rather finely, transversely strigose, the intervals broad, sparsely and finely punctate, from each puncture arises a short inconspicuous hair. Scutellum not very wide, sharply, transversely carinate. Elytra feebly narrowed to middle, behind which is a slight dilatation, then obliquely narrowed to apices, which are obtusely rounded and indistinctly serrulate; sides of abdomen visible from above; disk flattened, without distinct costæ, sutural edge elevated from apical third; humeri feeble, not carinate; basal depressions moderately deep and extending obliquely from behind the humeri to the suture; surface shining, rather finely and densely, imbricately granulate, smoother near apex, and rather densely clothed with distinct, short, yellowish, recumbent pubescence, but not concealing the surface sculpture. Body beneath piceous, with greenish metallic luster; prosternum finely rugose and feebly pubescent, with a longitudinal carina along middle extending into a blunt tooth between coxæ; prosternal lobe broadly rounded and subtruncate at middle; intercoxal process broad, sides strongly expanded behind coxæ, then abruptly narrowed to apex, which is obtuse; propleura with reticulate sculpture and feebly pubescent; metasternum finely punctate, strigose at the sides, the middle with a distinct, blunt, elongate tooth. Abdomen coarsely punctate and feebly strigose near base, smoother poste-

riorly, vaguely pubescent; first ventral segment convex, not impressed nor conspicuously pubescent; last ventral subtruncate at apex; vertical portions of the segments feebly pubescent; pygidium coarsely punctate, median carina well marked, but not projecting at apex. Hind tarsi three-fourths as long as tibiæ, the first joint fully as long as the four following joints united; anterior and middle tibiæ with a slight mucro at the inner apex, the posterior tibiæ simple; claws of anterior and middle tarsi cleft at apex, posterior claws cleft at middle, forming a rather broad tooth.

Length, 4.25 millimeters; width, 1.25.

Female.—Differs from the male by having the front of head cupreous, prosternum and metasternum without a tooth on median line, tibiæ simple, and the claws on all the feet cleft at the middle forming a broad tooth.

The type is a male from Mount Maquiling, Luzon (*Baker*). The paratypes are a male and two females in the United States National Museum collection labeled "Acc. No. 990, Bur. Agri. P. I., collected by C. R. Jones" and a male from Mount Banahao, Luzon (*Baker 8310*). There is also a male from Butuan, Mindanao (*Baker 8309*) and another male from Basilan Island (*Baker*), which are not quite typical, but are placed with the species for the present. The Bureau of Agriculture reports that No. 990 was collected at Lamao, Bataan Province, Luzon.

The male from Basilan differs from the type in being more cupreous, with the front of head less densely granulate and more shining, and with the disk of pronotum violaceous and more strongly strigose. The specimen from Mindanao has the prothoracic carina a little longer, the surface of the pronotum more strongly strigose, the elytra strongly rugose at sides, and the prosternal lobe feebly emarginate in front.

Agrilus butuanensis sp. nov.

Male.—Form short, rather robust, head green, pronotum piceous, with a strong aëneous tinge, elytra piceous, with a metallic tinge.

Antennæ cupreous, with the basal joints brassy, not quite reaching to middle of pronotum, serrate from the fourth joint. Head with the front wide, rather strongly convex, sides nearly parallel; vertex and occiput broadly and rather deeply impressed; surface shining and strongly rugose, intervals sparsely punctate, sparsely clothed with rather long, semierect, pale yellow hairs over entire surface. Clypeus slightly wider than

long, with the front margin slightly arcuate. Pronotum one-half wider than long, wider at base than apex; sides nearly straight, lateral margin strongly sinuate when viewed laterally; hind angles rectangular, with a sharply defined, arcuate carina, the carina extending to lateral margin at apical third; disk convex, with a vague, broadly transverse depression in front of scutellum; surface very finely and irregularly strigose, near sides more densely strigose-punctate, intervals rather densely and finely punctate, from each puncture arises a short, semierect, inconspicuous hair. Scutellum wide, strongly, transversely bicarinate. Elytra nearly parallel to just behind the middle, then strongly, obliquely narrowed to apices, which are conjointly rounded without serrulation, sides of abdomen entirely concealed from above; disk rather convex, slightly flattened posteriorly along suture, without distinct costæ, sutural margin feebly elevated near apex, humeral carina very short; basal depressions rather feeble; surface shining, coarsely and densely imbricately granulate, rather densely clothed with distinct, short, whitish, semierect pubescence. Body beneath piceous, with a strong aëneous tinge; prosternum coarsely rugose and feebly pubescent; prosternal lobe broadly rounded, and vaguely emarginate at middle; intercoxal process abruptly expanded behind coxæ, apex broad and biemarginate, with the median tooth more advanced in front than the sides; propleura coarsely, sparsely punctate, slightly strigose and vaguely pubescent; metasternum at sides coarsely punctate-strigose. Abdomen not as coarsely punctate-strigose as metasternum, becoming smoother posteriorly; first ventral segment convex, not impressed or more pubescent than the rest of abdomen; last segment feebly concave, deeply and acutely emarginate at apex; pygidium without projecting carina. Hind tarsi about one-half as long as the tibiæ, the first joint equal in length to the four following joints united; anterior and middle tibiæ distinctly mucronate at the inner apex, the posterior simple; claws divaricate, cleft close to apex on all the feet.

Length, 4.7 millimeters; width, 1.6.

Female.—Very similar to the male but differs in having the front of head bright cupreous, all the tibiæ simple, claws on all the feet cleft at middle forming a short, acute tooth, and by having the posterior tarsi shorter than in the male, not being one-half as long as the tibiæ.

Described from three males and one female. The type is a male from Butuan, Mindanao (*Baker 8307*). Allotype from the

same locality (*Baker 8306*). One male paratype from the type locality without any number and another male from Davao, Mindanao (*Baker 8320*).

Agrilus inermis sp. nov.

Form small, elongate, and slender, head and pronotum brassy green, elytra piceous, with a strong metallic luster, covered with short white hairs, except a broad transverse band at the middle.

Antennæ brassy green, reaching to the basal third of pronotum, serrate from the fourth joint. Head with the front slightly convex, sides slightly narrowed from vertex to clypeus; vertex and occiput broadly and rather deeply impressed; surface very finely and densely granulate, becoming less granulose and more coarsely punctate on occiput; in front of clypeus and along the eyes densely clothed with long pale yellow hairs. Clypeus nearly square, with the front margin nearly truncate. Pronotum quadrate, nearly as long as wide, base and apex equal in width; sides nearly straight; narrowly explanate; lateral margin feebly sinuate when viewed laterally; hind angles rectangular, with a sharply defined, abruptly angulate carina, the carina joining lateral margin just in front of middle; disk convex, with a vague median depression divided into two portions, and an indistinct depression at the sides; surface rather finely but coarsely and irregularly strigose, near the posterior angles more densely strigose-punctate, intervals sparsely and finely punctate, and very sparsely clothed with inconspicuous hairs. Scutellum not very wide, strongly, transversely carinate. Elytra slightly narrowed from the base, with a very feeble postmedian broadening, then more obliquely narrowed to the apices, which are subtruncate and without distinct serrulation, sides of abdomen exposed above; disk flattened, with an elongate concave space along suture at the middle, without distinct costæ; sutural margin elevated from about the apical third, with a sharply elevated carina extending from the humeri to the basal third, on a line with the prothoracic carina; basal depressions moderately deep and extending obliquely behind the scutellum to the suture; surface rather shining, finely granulate-punctate, sparsely clothed with distinct short whitish pubescence, except for a broad transverse denuded band at the middle. Body beneath piceous, with a strong brassy tinge; prosternum sparsely punctate and feebly scabrous; prosternal lobe obtusely angulate in front, with a very minute tooth along margin on each side

of median line; intercoxal process abruptly expanded behind the coxæ, then arcuately emarginate to the apex, which is acute and distinctly more advanced in front than the sides; propleura coarsely punctate and strigose; metasternum at sides strongly punctate-strigose. Abdomen not quite as coarsely punctate-strigose as the metasternum, the strigæ finer and more sparsely placed toward apex, nearly glabrous; first ventral segment convex, not impressed or pubescent; last segent subtruncate at apex; vertical portions of the segments vaguely punctate and nearly glabrous, except the first, which is rather densely pubescent; pygidium feebly carinate along median line, the carina not projecting. Hind tarsi two-thirds as long as tibiæ; first joint as long as the four following joints united; anterior and middle tibiæ arcuate, with a slight mucro at the inner apex, the posterior simple; claws on all the tarsi cleft near the apex.

Length, 4 millimeters; width, 1.1.

Described from a unique specimen, which is probably a male, from Puerto Princesa, Palawan (*Baker 8311*).

Agrilus minutus sp. nov.

Male.—Form very small and slender, head green, pronotum cupreous, with a purple tinge, elytra brassy green, with a broad, transverse purplish band at apical third.

Antennæ slightly aëneous, reaching to basal third of pronotum, serrate from the fourth joint. Head with the front rather narrow, slightly convex, sides nearly parallel, slightly, arcuately emarginate from vertex to clypeus; occiput slightly, longitudinally impressed; surface dull, finely and densely granulate, becoming finely rugose on the occiput, with a few sparsely placed punctures on the front and sparsely clothed behind the clypeus with short, pale yellow pubescence. Clypeus narrow, with the front margin truncate. Pronotum nearly one-half wider than long, narrower at base than apex, sides arcuate from apex to base; lateral margin very nearly straight; hind angles rectangular, with a sharply defined sinuate carina, the carina joining the lateral margin near the apical angles; disk convex, the median line with an indistinct anterior and posterior depression, a feeble, oblique depression at the side; surface finely and irregularly strigose, densely punctate at sides and posterior angles, intervals between the strigæ sparsely and rather coarsely punctate. Scutellum sharply, transversely carinate. Elytra slightly narrowed from the base with a very feeble

postmedian broadening, then more obliquely narrowed to the apices, which are separately, obtusely rounded, not distinctly serrulate, sides of abdomen nearly concealed from above; disk feebly flattened, without distinct costæ; sutural margin elevated at the apical third; with a sharply elevated carina extending from the humeri to near the middle on a line with the prothoracic carina, basal depressions moderately deep; surface rather shining, finely and densely, imbricately granulate, becoming nearly smooth on the dark transverse area, sparsely clothed with distinct, short, whitish, semierect hairs, except for a broad transverse denuded band at the apical third. Body beneath aëneous; prosternum sparsely, finely punctate and feebly scabrous; prosternal lobe broadly rounded in front; intercoxal process expanded behind coxæ, then obliquely narrowed to the apex, which is obtuse; propleura finely, reticulately punctate and vaguely pubescent; metasternum at side rather finely punctate-strigose. Abdomen more finely punctate-rugose than the metasternum; first ventral segment convex, not impressed or conspicuously pubescent; last segment very deeply and acutely emarginate at the apex; vertical portions of the segments finely punctate and nearly glabrous; pygidium without projecting carina at apex. Hind tarsi missing; tibiæ not mucronate. (Claws missing in all the feet.)

Length, 3.25 millimeters; width, 1.

Described from a single male specimen from Puerto Princesa, Palawan (*Baker*).

Agrilus pulcher Deyrolle.

This species is represented in the collection by a male specimen from Davao, Mindanao (*Baker*).

Agrilus immaculatus sp. nov.

Female.—Form small, elongate, and rather slender, olivaceous bronze.

Antennæ aëneous, serrate from the fourth joint (broken off at ninth joint). Head with the front rather wide, strongly convex, sides nearly parallel; vertex and occiput slightly, longitudinally impressed, the impression extending from occiput to near clypeus, and becoming nearly obliterated anteriorly except for a small round depression at middle of front; surface finely, densely granulate and sparsely punctate on the front, becoming finely, densely punctate on the anterior pubescent area and finely rugose on the vertex and occiput, densely clothed

behind the clypeus with short, erect, white hairs. Clypeus a little wider than long, with the front margin slightly, arcuately emarginate. Pronotum a little more than one-half wider than long, base and apex nearly equal in width, sides slightly arcuate; lateral margin feebly sinuate; hind angles rectangular, with a well-defined, sinuate carina, the carina close to lateral margin and joining it near the apical angles; disk convex, a moderately deep impression behind the front angles, and on the median line two depressions, the antescutellar one much deeper and larger than the anterior one, which is nearly obsolete; surface rather finely and irregularly strigose, the intervals between the ridges rather densely and finely punctate. Scutellum rather wide, sharply, transversely bicarinate. Elytra slightly sinuate behind the humeri, with a feeble postmedian dilatation, then obliquely narrowed to the apices, which are conjointly, obtusely rounded without serrulation, sides of abdomen narrowly visible from above; disk feebly flattened, slightly concave posteriorly along suture, without distinct costæ, sutural edge elevated behind the middle, with a sharply elevated carina extending from humeri to the basal third and on a line with the prothoracic carina; basal depressions deep; surface subopaque, finely and densely, imbricately granulate, rather densely clothed with distinct, short, whitish, recumbent pubescence. Body beneath aëneous, more shining than above; prosternum finely, densely scabrous, and very vaguely pubescent; prosternal lobe broadly rounded in front; intercoxal process gradually, obliquely expanded to behind coxæ, then abruptly narrowed to the apex, which is rather obtuse; propleura coarsely and densely, reticulately punctate; metasternum rather strongly, densely punctate-strigose and feebly pubescent. Abdomen more sparsely punctate-strigose than metasternum, the strigæ becoming finer posteriorly; first ventral segment convex; not impressed or more pubescent than rest of surface; last segment very obtusely rounded at apex; vertical portions of segments evenly and very vaguely pubescent; pygidium without projecting carina. Hind tarsi about one-half as long as the tibiæ, the first joint about equal in length to the four following joints united; tibiæ simple; claws on all the feet cleft at middle forming a rather long, acute tooth.

Length, 4.3 millimeters; width, 1.25.

Described from a unique female from Mount Maquiling, Luzon (*Baker*).

Agrilus malinaoensis sp. nov.

Female.—Form short and robust, color dark coppery, with a slight purplish tinge; each elytron with an indistinct, white, pubescent spot along suture near apex.

Antennæ piceous, not quite reaching to middle of pronotum, serrate from the fourth joint. Head with the front rather narrow, moderately convex, the sides strongly narrowed from clypeus to occiput; a feeble impression extending from occiput to near clypeus; surface strongly rugose, intervals very finely granulate, sparsely and rather coarsely punctate, rather densely clothed behind the clypeus with very short white hairs. Clypeus elevated, wider than long, with the front margin broadly and rather deeply, arcuately emarginate. Pronotum a little more than one-half as wide as long, base and apex about equal in width; sides feebly arcuate; lateral margin nearly straight; hind angles rectangular, with a sharply defined, strongly sinuate carina, the carina extending to lateral margin near apical angles; disk convex, with three depressions, a broadly oval one in front of scutellum and a less distinct basal one on each side along inner side of lateral carina; surface rather finely, transversely strigose, the intervals sparsely and finely punctate, with a few short, semierect, inconspicuous hairs. Scutellum not very wide, strongly, transversely carinate. Elytra with a slight posthumeral sinuation, behind which there is a slight dilatation, then strongly, obliquely narrowed to apices, which are conjointly, obtusely rounded and very finely serrulate, sides of abdomen exposed above; disk slightly flattened, narrowly concave along suture at apical third, without distinct costæ, sutural margin elevated from apical third, humeral carinæ very short, slightly sinuate posteriorly; basal depressions moderately deep; surface opaque, finely and densely, imbricately granulate, sparsely clothed with short, inconspicuous, recumbent hairs, each elytron with an indistinct, white pubescent spot along the suture near apex. Body beneath aëneous, more shining than above; prosternum coarsely, densely scabrous and sparsely pubescent; prosternal lobe wide, broadly subtruncate in front; intercoxal process very abruptly expanded behind the coxæ, the apex wide and deeply biemarginate; propleura finely punctate, slightly strigose, without pubescence; metasternum coarsely punctate-strigose, with a smooth elongate space at middle. Abdomen densely, transversely strigose, with fine punctures along the edge of the strigæ, and rather densely clothed with

short white hairs; first ventral segment convex, not impressed nor more conspicuously pubescent than rest of surface; last segment rather widely, but not deeply, arcuately emarginate at apex; vertical portions of the segments rather densely punctate and sparsely pubescent; pygidium finely, densely punctate, with a well-defined median carina, which does not project at the apex. Hind tarsi about one-third as long as the tibiæ; the first joint about as long as the two following joints united; anterior and middle tibiæ straight, with a mucro at the apex, posterior tibiæ feebly arcuate; femora abruptly narrowed near the apex; claws on all the feet cleft at middle forming a rather broad tooth, which is not incurved.

Length, 5.25 millimeters; width, 1.7.

Described from two females from Malinao, Tayabas Province, Luzon (*Baker*).

Agrilus iliganensis sp. nov.

Male.—Form short, not quite as robust as *A. butuanensis,* olivaceous bronze.

Antennæ brassy green, reaching to middle of pronotum, serrate from the fourth joint. Head with the front narrow and slightly convex, the sides strongly narrowed from clypeus to occiput, without a distinct median impression; surface densely and coarsely rugose, intervals sparsely, coarsely punctate and rather densely clothed behind the clypeus with long white hairs. Clypeus a little wider than long, with the front margin broadly and rather deeply, arcuately emarginate. Pronotum a little more than one-half wider than long, base and apex nearly equal in width; sides feebly arcuate; lateral margin very nearly straight; hind angles rectangular, with a well-defined, strongly angulate carina, the carina reaching lateral margin near the apical angles; disk convex, with a broad and rather deep median depression, extending from base nearly to apex, and a less distinct basal depression on each side along the inner margin of the lateral carina; surface finely, rather closely and irregularly strigose, the intervals finely granulate, rather densely, coarsely punctate and sparsely clothed with short, semierect, inconspicuous hairs. Scutellum not very wide, sharply, transversely carinate. Elytra nearly parallel to just behind the middle, then arcuately narrowed to apices, which are conjointly, broadly rounded without serrulation, sides of abdomen narrowly exposed above; disk somewhat flattened and concave along the suture, more narrowly and deeply concave posteriorly, without distinct costæ, sutural

edge elevated behind the middle, humeral carina short, indistinct posteriorly; basal depressions moderately deep; surface subopaque, finely and densely, imbricately granulate, rather densely clothed with short, white, inconspicuous hairs. Body beneath more shining and greenish than above; prosternum finely, densely scabrous, sparsely clothed along middle with long suberect pubescence; prosternal lobe wide, broadly subtruncate in front; intercoxal process very abruptly expanded behind the coxæ, the apex wide and deeply biemarginate; propleura finely, sparsely punctate and slightly strigose; metasternum densely and coarsely punctate-strigose. Abdomen less densely punctate-strigose than metasternum, the strigæ becoming finer posteriorly, coarsely pubescent; first ventral segment convex, not impressed or conspicuously pubescent; last segment feebly emarginate at apex; vertical portion of the segments evenly, sparsely pubescent; pygidium finely punctate, carinate along the median line, the carina not projecting at apex. Hind tarsi about one-half as long as the tibiæ, the first joint about as long as the two following joints united, anterior tibiæ with a feeble mucro at the tip, the middle and posterior simple; femora feebly, abruptly narrowed near apex; claws of anterior and middle tarsi cleft near apex, posterior claws cleft near middle forming a rather long, acute tooth, which is not incurved.

Length, 4 millimeters; width, 1.75.

Female.—Very similar to the male, but differs from it by having the front of head more coppery, antennæ a little shorter, prosternum not quite as pubescent at middle, tibiæ simple, and the claws on all the tarsi cleft at middle, forming a long, acute tooth.

The type, which is a male, is from Davao, Mindanao (*Baker 8360*); allotype from Iligan, Mindanao (*Baker 8305*). Other specimens without numbers collected by Baker are as follows: Another male from the type locality, a male from Zamboanga, Mindanao; a male from Mount Banahao, Luzon; and a female from Puerto Princesa, Palawan. The last specimen is provisionally referred to this species.

In some of the specimens the front margin of the clypeus is nearly truncate. The specimen from Palawan is not quite typical and may represent another species, but for the present it is placed with this species. It has the front of the head nearly smooth and very densely clothed with long yellowish pubescence behind the clypeus, the pronotum less depressed on the median line, and the claws a little more sharply cleft.

Agrilus davaoensis sp. nov.

Male.—Form elongate, rather slender, olivaceous bronze varying to cupro-aëneous.

Antennæ greenish black, nearly attaining the hind angles of pronotum, serrate from the fourth joint. Head with the front rather narrow and slightly convex, the sides parallel from occiput to middle of front, then strongly narrowed to clypeus; occiput moderately impressed, the impression extending to middle of the front; surface coarsely, transversely rugose, intervals sparsely and coarsely punctate, nearly glabrous. Clypeus strongly elevated, slightly wider than long, with the front margin broadly, arcuately emarginate. Pronotum one-half wider than long, slightly narrower at base than apex; sides rather strongly arcuate from apex to base; lateral margin feebly sinuate when viewed laterally; hind angles rectangular, with a sharply defined sinuate carina, the carina joining the lateral margin a little in front of middle; disk convex, a feeble, oblique depression extending from lateral margin to base along inner side of lateral carina, and on the median line two depressions, the antescutellar one the larger; surface rather coarsely, closely, transversely strigose, the intervals between the strigæ sparsely and finely punctate. Scutellum sharply, transversely carinate. Elytra slightly sinuate behind the humeri, a little broadened behind the middle, then obliquely narrowed to apices, which are separately and rather acutely rounded, without serrulation, sides of abdomen exposed; disk rather convex, without distinct costæ, sutural margin elevated, from the middle, with a sharply elevated carina extending from the humeri to near the middle, on a line with the prothoracic carina; basal depressions deep; surface shining, densely, closely, imbricately granulate, and rather densely clothed with distinct short, whitish, semierect pubescence. Body beneath piceous, with a strong brassy metallic luster; prosternum coarsely, densely scarbrous and vaguely pubescent; prosternal lobe wide, broadly subtruncate in front; intercoxal process broad, sides gradually widened behind the coxæ, then abruptly narrowed to apex, which is obtuse; propleura densely, coarsely punctate and moderately strigose; metasternum densely, coarsely punctate-strigose and rather densely pubescent. Abdomen sparsely and rather finely punctate-strigose, the strigæ becoming. finer posteriorly, very sparsely clothed with short pubescence; first ventral segment convex, not impressed nor conspicuously pubescent; last segment feebly emarginate at apex; vertical portions of segments vaguely

pubescent; pygidium finely punctate and feebly carinate along the median line, the carina not projecting. Hind tarsi about one-half as long as the tibiæ; the first joint about as long as the four following joints united; anterior and middle tibiæ slightly mucronate at the inner apex, posterior tibiæ simple; claws on all the tarsi cleft near apex, the lower portions not incurved.

Length, 5.25 millimeters; width, 1.5.

Female.—Differs from the male in having the head and pronotum coppery, tibiæ simple, and the claws on all the tarsi cleft near middle, forming a rather broad tooth.

Described from three males and one female. The type is a male from Davao, Mindanao (*Baker 8369*); the allotype and two male paratypes are from the same locality without a number.

Agrilus mindanaoensis sp. nov.

Male.—Form small, elongate, and rather slender, color olivaceous bronze varying to cupro-aëneous.

Antennæ varying from aëneous to cupreous, nearly attaining hind angles of pronotum, serrate from the fourth joint. Head with the front rather convex, the sides nearly parallel, slightly, arcuately emarginate from vertex to clypeus; vertex rather deeply and broadly impressed, the impressed line not extending to the middle of the front; surface finely, densely granulate with a few rather large punctures intermixed, somewhat rugose on the occiput, and a wide transverse band along front margin smooth, densely, finely punctate, and densely clothed with short white to pale yellow hairs, the pubescence extending along margin of eyes. Clypeus slightly wider than long, with the front margin nearly truncate. Pronotum quadrate, nearly as long as wide, base and apex equal in width, sides nearly straight, narrowly explanate; lateral margin very nearly straight; hind angles rectangular, with a sharply defined, strongly arcuate carina, the carina joining the lateral margin a little in front of middle; disk convex, a moderately deep oblique depression extending from lateral margin to base along inner side of lateral carina, and a vague median depression extending from base nearly to apex, slightly interrupted at middle; surface rather finely and irregularly strigose, the intervals between the ridges sparsely and finely punctate. Scutellum not very wide, transversely carinate. Elytra sinuate behind the humeri; scarcely dilated behind the middle, then obliquely narrowed to apices, which are conjointly, obtusely rounded, without serrulation; sides of abdomen visible from above; disk feebly flattened,

without distinct costæ, sutural margin feebly elevated behind the middle, with a sharply elevated carina extending from the humeri to the basal third; basal depressions moderately deep; surface subopaque, finely and densely, imbricately granulate, sparsely clothed with distinct, short whitish hairs. Body beneath aëneous, more shining than above; prosternum finely and rather sparsely scabrous, nearly glabrous; prosternal lobe vaguely emarginate; intercoxal process with the sides slightly expanded behind the coxæ, then narrowed to apex, which is rather acute, surface feebly concave, with the sides slightly elevated; propleura sparsely and rather coarsely punctate; metasternum at sides coarsely and sparsely punctate-strigose, much smoother along the middle. Abdomen coarsely punctate-strigose on first segment, becoming rapidly finer toward apex; first ventral segment convex, with a very vague elevation at middle, not conspicuously pubescent, last segment broadly subtruncate; vertical portions of the segments feebly punctate and nearly glabrous; pygidium feebly carinate along the median line, the carina not projecting. Hind tarsi nearly two-thirds as long as the tibiæ, the first joint as long as the four following joints united; anterior and middle tibiæ feebly arcuate, mucronate at the inner apex, posterior tibiæ simple; claws on anterior and middle tarsi cleft near apex, posterior claws cleft at middle, forming a rather broad tooth, which is not incurved.

Length, 4 to 4.75 millimeters; width, 1 to 1.3.

Female.—Differs from the male in having the front of head plumbeous, smoother and scarcely pubescent, tibiæ simple, and by having the claws on all the feet cleft near the middle.

Described from five males and five females. The type, allotype, and one male and one female paratype from Davao, Mindanao (*Baker*). One male and one female from Butuan, Mindanao (*Baker 8312*); two males and one female from Iligan, Mindanao (*Baker 8303*); and one female from Puerto Princesa, Palawan (*Baker*).

This seems to be a rather variable species. In some of the specimens the vertex is slightly gibbose on each side of the median impression, tips of elytra separately rounded and feebly serrulate, the prosternal lobe scarcely emarginate in front, the intercoxal process flat, and some have a more coppery tinge than others. The male specimens from Iligan have the pronotum of a dark plumbeous color, with a greenish tinge along the base, more finely strigose and without distinct median depression, the elytra feebly concave along suture and with the apices

separately, rather acutely rounded and feebly serrulate. The female from Puerto Princesa differs from the allotype in having the front of head wider and not quite as strongly impressed on vertex.

Genus CORAEBUS Castlenau and Gory

Key to the species.[6]

1. Pronotum with lateral carina ..... 2.
   Pronotum without lateral carina ..... 3.
2. Elytra with transverse pubescent bands ..... C. azureus sp. nov.
   Elytra without transverse pubescent bands ..... C. melibaeiformis Saund.
3. Elytra rounded at apex ..... C. piperi sp. nov.
   Elytra deeply emarginate at apex ..... 4.
4. Elytra with large triangular cupreous band bordered with violet; color green ..... C. bajulus Deyr.
   Elytra with transverse band of white pubescence at apical third; color green or blue ..... C. spinosus Cast. and Gory.

Coraebus azureus sp. nov.

Short, moderately convex, brilliant blue, elytra with transverse bands of white pubescence; beneath greenish blue, legs coppery, with a greenish reflection.

Head produced in front beyond the eyes, widely and deeply channeled, sparsely punctate-reticulate and sparsely clothed with short white curved hairs, which are hardly visible on the occiput, except from the side. Pronotum much wider than long, narrower in front than behind; disk convex and regularly rounded, with the sides narrowly depressed in front, and more widely at the posterior angles, the depression extending along base to near the middle; lateral margin regularly arcuate and finely crenulate; anterior margin strongly, arcuately emarginate, with the median lobe strongly angulate at middle; base strongly bisinuate, with a broadly rounded median lobe in front of scutellum, the posterior angles broadly rounded; surface strongly punctate and irregularly rugose, sparsely clothed with inconspicuous black hairs, becoming cinereous toward lateral margin; lateral carina short and strongly arcuate. Scutellum cordate, transversely rugose. Elytra about equal in width to pronotum, slightly convex, with a deep depression along base, a similar one along lateral margin behind humerus, and a broad, shallow one

[6] The following species of this genus reported from the Philippines have not been seen by me: *Coraebus cisseoides* Saund., *C. caelestis* Saund., *C. hastanus* Cast. and Gory, *C. pullatus* Saund., and *C. transversus* Kerrem.

along suture near apex; sides nearly parallel to apical third, then arcuately attenuate to tips, which are conjointly, broadly rounded; lateral margin finely crenulate anteriorly, becoming strongly dentate toward apex; surface strongly imbricate, becoming scabrous toward apex, sparsely clothed with short, black, curved hairs, which are scarcely visible, except when viewed from the side, and also marked with broader cinereous hairs arranged as follows: Each elytron with three small spots at middle forming a triangle, a distinct transverse band at apical fourth, and a small spot near apex. Beneath coarsely imbricate, and sparsely clothed with short, recumbent, cinereous hairs.

Length, 7.5 millimeters; width, 3.

Described from one specimen from Baguio, Benguet, Luzon (*Baker*).

This species is closely allied to *C. melibaeiformis* Saund., but differs from that species by being more elongate and having the elytra marked with transverse bands of cinereous pubescence.

Coraebus melibaeiformis Saunders.

One specimen in the United States National Museum collection labeled "Lamao, Luzon, P. I., III–VI, 1911, C. V. Piper, collector."

Coraebus bajulus Deyrolle.

Two specimens in the United States National Museum collection labeled "Negros Island, P. I., May 1911, C. V. Piper, collector."

Coraebus spinosus Castelnau and Gory.

One specimen from Davao, Mindanao (*Baker 8319*), and another specimen from Dapitan, Mindanao (*Baker 11976*).

Coraebus piperi sp. nov.

Large, robust, moderately convex, resembling the genus *Cisseis*, olive green, head, side of pronotum, and spots on elytra of a very dense ochraceous pubescence; beneath aëneous, densely clothed with ochraceous pubescence.

Head with the front and vertex deeply, broadly grooved, coppery, and coarsely punctate, with the concavity filled with long, recumbent, ochraceous pubescence; occiput green, coarsely, deeply punctate, and sparsely clothed with inconspicuous long black hairs; antennæ coppery, reaching to apical third of pronotum. Pronotum wider than long, narrower in front than behind; sides regularly arcuate, with the lateral margin finely crenulate, and

the posterior angles obtusely angulate; anterior margin deeply, arcuately emarginate, with the median lobe broadly rounded, the anterior angles acute; base deeply bisinuate, with the broadly rounded median lobe truncate in front of scutellum; disk strongly convex and regularly rounded, with the sides widely depressed and densely clothed with long, recumbent, ochraceous hairs; rest of surface coarsely, deeply punctate, from each puncture arises a long, recumbent, black hair, which is scarcely visible, except from the side; lateral carina absent. Scutellum cordate, impunctate. Elytra about equal in width to pronotum, slightly convex, with a deep triangular depression along base near humerus, and another shallow elongate one along suture, extending from apical fourth to the apex; sides strongly sinuate in front of middle, strongly expanded at apical third, then attenuate to the tips, which are conjointly, broadly rounded; lateral margin finely crenulate to about the middle, then strongly dentate to apex; surface scabrous-punctate, becoming smoother along suture on basal half, and with the pubescent areas finely, densely punctate, sparsely clothed with short black curved hairs, which are scarcely visible, except when viewed from the side, and also marked with patches of densely placed, recumbent, ochraceous pubescence arranged as follows: Each elytron with a triangular basal area, filling the basal depression and continuing on a line with the pubescence on side of pronotum, a round spot on middle of disk at basal third, two similar ones along lateral margin, one at about the middle and the other midway between it and the apex, another round spot along suture at apical third, and an oblong spot near apex, reaching from lateral margin obliquely forward to near the suture, but not quite reaching it. Abdomen beneath coarsely, densely punctate, with the sides densely clothed with long, recumbent, ochraceous pubescence. Legs of a darker bronze color than the abdomen; tarsi shining black.

Length, 10 millimeters; width, 4.

One specimen in the United States National Museum collection labeled "Lamao, Luzon, P. I., III–VI, 1911, C. V. Piper, collector." The species is named for the collector.

This species is allied to *C. cisseoides* Saund., but differs from that species by having the triangular basal depression of elytron densely clothed with ochraceous pubescence and by having six distinct pubescent spots on each elytron, instead of five, as in *cisseoides*.

Genus **AMORPHOSOMA** Castelnau

Amorphosoma marmoreus Deyrolle.

I have determined two specimens as of this species; one from Mount Banahao, Luzon (*Baker 8353*), and the other one from Butuan, Mindanao (*Baker 8352*).

These two specimens differ slightly in a number of ways, but the markings are identical and they are probably only sexes of the same species. Deyrolle gives this species as having a wide distribution in the Malaysian islands, but the specimens before me do not quite agree with his description in regard to the elytral tips. In his figures [7] he shows this species as having the elytral tips strongly spinose at the sutural angles, but in his description he gives the following:

> L'extrémité qui est tronquée, denticulée et fortement épineuse à peu de distance de la suture, cette forte épine disparaissant chez certains exemplaires de taille médiocre.

The specimen from Butuan measures 11 millimeters in length, with the tips of the elytron slightly rounded at the angles and the margin evenly, strongly dentate, the lamellælike scales on elytra quite prominent and with six gibbosities on the pronotum; while the specimen from Mount Banahao measures only 8.5 millimeters in length, the dentations on tips of elytron are larger and more separated, the lamellælike scales on elytra are not very prominent, and with eight gibbosities on the pronotum, two of which are not very prominent.

Genus **SAMBUS** Deyrolle

Key to the species. [8]

1. Head with vertex distinctly gibbose ..... **S. gibbosus sp. nov.**
   Head with vertex not distinctly gibbose ..... 2.
2. Surface of elytra bicolored ..... 3.
   Surface of elytra unicolored ..... 4.
3. Elytra with a reddish purple spot along lateral margin. **S. bakeri sp. nov.**
   Elytra with irregular black and green designs ..... **S. parallelus sp. nov.**
4. Elytra bronzy ..... 5.
   Elytra blue or black ..... 6.
5. Pubescence on elytra uniform, not forming distinct designs. **S. confusus sp. nov.**
   Pubescence on elytra forming distinct designs, especially on apical part. **S. ornatus sp. nov.**

[7] Ann. Soc. Ent. Belg. 8 (1864) pl. 4, fig. 14.

[8] *Sambus auricolor*, described by Saunders from Luzon, has not been seen by me.

6. Elytra blue..... S. fasciatus sp. nov.
   Elytra black..... 7.
7. Pronotum and elytra uniformly colored..... 8.
   Pronotum coppery; elytra black..... 9.
8. Pubescence on elytra forming a transverse row of four ring-shaped spots at the apical fourth..... S. luzonicus sp. nov.
   Pubescence on elytra forming a transverse zigzag band at apical third, behind which is a solid transverse band..... S. nigricans sp. nov.
9. Pubescence above consisting of white hairs..... S. aeneicollis sp. nov.
   Pubescence above consisting of yellow hairs or with white and yellow hairs intermixed..... S. lugubris Saund.

Sambus gibbosus sp. nov.

Small, rather elongate, head and pronotum bright reddish purple, the former with the front bright green, the latter with a faint greenish tinge along the lateral margin; elytra coppery bronze and marked with irregular designs of white and pale yellow pubescence, the transverse zigzag band at apical fourth very distinct; beneath bronzy green and clothed with short white pubescence.

Head broadly grooved for its entire length, strongly gibbose on vertex, slightly rugose and densely, finely granulate, rather evenly clothed with long white pubescence, the hairs becoming finer and sparser on occiput; antennæ green, reaching to middle of pronotum; clypeal suture distinct; epistoma very narrow between antennæ. Pronotum much wider than long, narrower in front than behind; sides flattened and regularly arcuate, with the lateral margin crenulate; anterior margin bisinuate, with the median lobe broadly rounded; base bisinuate, with a large median lobe in front of scutellum; lateral carina nearly straight and perpendicular to base, reaching from posterior angles to a little beyond the middle; disk strongly convex anteriorly; surface coarsely punctate, concentrically rugose, and sparsely clothed with inconspicuous dark hairs on disk, the sides more densely clothed with long white hairs. Scutellum large, triangular, cupreous, and finely, transversely carinate. Elytra narrower at base than middle of pronotum, rather convex; sides strongly sinuate at posterior coxæ, expanded at apical third, then strongly attenuate to tips, which are conjointly, broadly rounded and finely dentate; surface strongly imbricate, becoming less distinct posteriorly, and clothed with pubescence which is arranged as follows: Each elytron with a small round patch of silvery white hairs at basal third near suture, but separated from it, a similar patch of pale yellow hairs behind these at the middle, a very distinct transverse zigzag band of similar white hairs at apical

fourth, behind which is a short transverse row of recumbent white hairs near suture, balance of surface sparsely clothed with fine inconspicuous yellow hairs, becoming darker and slenderer toward apex. Abdomen strongly punctate and finely rugose.

Length, 4 millimeters; width, 1.5.

Described from a unique specimen from Butuan, Mindanao (*Baker*).

This species differs from all the other species examined by its head being strongly gibbose on the vertex and the epistoma very narrow between the eyes, which are nearly contiguous.

Sambus bakeri sp. nov.

Rather robust, uniformly cupreous, except head which is brilliant reddish purple; each elytron with a large, oblong, lateral spot of a beautiful reddish purple color; beneath cupreous, with a slight purplish reflection, sparsely clothed with short white hairs.

Head deeply grooved, the groove becoming less distinct on the front, slightly, transversely rugose, sparsely, finely punctate and clothed with pale yellow pubescence, becoming denser and longer on the occiput; antennæ coppery, reaching to middle of pronotum; clypeal suture distinct; epistoma wide, transverse between antennæ. Pronotum much wider than long, distinctly narrower in front than behind; sides flattened and regularly arcuate, with the lateral margin crenulate; anterior margin bisinuate, with the median lobe broadly rounded; base strongly bisinuate, with the median lobe rather abruptly rounded in front of scutellum; lateral carina slightly arcuate, reaching perpendicularly from the posterior angles to apical fourth; disk convex anteriorly, broadly concave posteriorly, with a rather deep depression inside of lateral carina reaching from base to median part; surface strongly punctate and concentrically rugose, densely clothed with long, yellowish, recumbent pubescence. Scutellum large, triangular; surface finely reticulate. Elytra narrower at base than middle of pronotum, rather convex; sides nearly parallel to middle, strongly expanded at posterior third, then arcuately attenuate to tips, which are conjointly, broadly rounded and finely dentate; surface finely imbricate, with a shallow depression extending obliquely from base to suture at basal fourth, and another near suture at apical fifth; a semioblong spot of brilliant reddish purple along lateral margin of each elytron, extending from humeral angle to apical third and internally to the median part and clothed with inconspicuous, fine black hairs, rest of surface of a uniformly bright coppery color and densely clothed with

semierect pale yellow hairs, which are broader than those on the reddish parts. Abdomen finely punctate and rugose.

Length, 5.25 millimeters; width, 2.

Described from two specimens. The type is from Mount Maquiling, Luzon (*Baker*); paratype from Butuan, Mindanao (*Baker*).

In the specimen from Mindanao the pubescence on the elytra is white instead of pale yellow, but otherwise the two specimens are identical.

Sambus parallelus sp. nov.

Slender, nearly parallel, head and pronotum brassy green, the former with the front of a brighter green; surface of elytra black and brassy green, forming distinct designs; beneath black, with bronzy tinge, nearly glabrous.

Head deeply grooved its entire length, strongly, transversely rugose, and sparsely clothed with long white pubescence, becoming finer and slightly yellow on the occiput; antennæ coppery, reaching to basal third of pronotum; clypeal suture indistinct; epistoma wide, transverse between antennæ. Pronotum much wider than long, about as wide in front as behind; sides flattened and arcuate, slightly sinuate posteriorly, with the lateral margin crenulate; anterior margin bisinuate, with a broadly rounded median lobe; base strongly bisinuate, with a large median lobe, truncate in front of scutellum; lateral carina strongly arcuate, reaching perpendicularly from posterior angles to middle; disk convex, limited at basal third by a widely rounded transverse depression, becoming deeper near lateral carina; surface concentrically rugose on the disk and very densely punctate on the inside of the lateral carina, sparsely clothed with yellowish hairs, becoming white in front of scutellum. Scutellum violaceous black, large and triangular; surface finely reticulate. Elytra a little narrower at base than middle of pronotum, rather convex, with a wide depression along suture at apical fifth; sides strongly sinuate at posterior coxæ, expanded at apical third, then arcuately attenuate to the tips, which are conjointly, broadly rounded and rather strongly dentate; surface strongly imbricate, indistinctly clothed with minute black hairs and distinctly marked with brassy green areas, these brassy areas clothed with white and yellow pubescence as follows: Each elytron with a narrow irregular band along base and suture, reaching to the apical third and connected to a similar band along the lateral margin by three irregular and broken transverse bands on the

basal half, at the apical fourth the transverse band from lateral margin to median part, then bent abruptly forward to suture at apical third, and the entire apical fifth except for an inclosed oblong dark area. Beneath nearly smooth, except median part of first two abdominal segments, which are longitudinally grooved, densely, finely punctate, and clothed with a row of dense erect hairs.

Length, 4 millimeters; width, 1.25.

Described from a single specimen from Mount Maquiling, Luzon (*Baker*).

Sambus confusus sp. nov.

Small, rather slender, entirely bright aëneous above, except front of head, which is bright green, becoming slightly bronzy on the occiput, rather evenly clothed with short, pale yellow, recumbent hairs, but not forming distinct designs; beneath bright brassy green, clothed with silvery white pubescence.

Head flat in front, rather deeply grooved on vertex and occiput, slightly rugose, finely, densely granulate and evenly clothed with moderately long white pubescence; antennæ greenish, reaching to middle of pronotum; clypeal suture distinct; epistoma wide, transverse between the antennæ. Pronotum much wider than long, a little narrower behind than in front; sides slightly flattened and regularly arcuate, with the lateral margin crenulate; anterior margin slightly bisinuate, the median lobe nearly straight and the anterior angles advanced forward and acute; base bisinuate, with a broadly rounded median lobe in front of scutellum; lateral carina slightly arcuate, nearly parallel with the lateral margin and reaching from base near posterior angle to the apical fourth; disk convex, with a rather deep depression on inside of lateral carina, reaching from base to median part; surface slightly rugose, densely punctate and densely clothed with short, yellow, recumbent hairs. Scutellum large, triangular; surface finely reticulate. Elytra at base about equal in width to pronotum, rather convex, without any distinct depressions; sides nearly parallel to middle, slightly expanded at apical third, then arcuately attenuate to tips, which are separately rounded and finely dentate; surface finely rugose and rather densely clothed with short, pale yellow, recumbent pubescence, forming very indistinct transverse zigzag bands near apex. Abdomen sparsely, finely punctate.

Length, 4 millimeters; width, 1.25.

Described from a single specimen from Baguio, Benguet Province, Luzon (*Baker 8330*).

Sambus ornatus sp. nov.

Rather robust, head and pronotum brilliant green in the male, coppery in the female; pronotum bronzy; elytra bronzy and marked with irregular patches of white or pale yellow hairs, these pubescent areas becoming transverse near apical part; beneath bronzy, clothed with short white pubescence.

Head with front slightly rounded, slightly grooved on vertex and occiput, densely punctate, finely, densely granulate and sparsely clothed with short white pubescence in male, yellow in female; antennæ green in male, bronzy in female, reaching to middle of pronotum; clypeal suture distinct; epistoma wide, transverse between the antennæ. Pronotum much wider than long, slightly narrower in front than behind; sides slightly flattened and regularly arcuate, with the lateral margin crenulate; anterior margin bisinuate, with the median lobe broadly rounded; base bisinuate, with the median lobe broadly rounded in front of scutellum; lateral carina arcuate, reaching from posterior angle to apical fourth; disk convex anteriorly, with a rather deep depression on the inside of the lateral carina, reaching from base to median part; surface densely punctate, finely rugose and sparsely clothed with very fine white pubescence in the male, pale yellow in the female. Scutellum large, triangular, dark bronzy; surface finely reticulate. Elytra at base about equal in width to pronotum at middle, rather convex, with a slight depression along lateral margin behind the humerus; sides parallel to middle, expanded at apical third, then arcuately attenuate to the tips, which are separately rounded and finely dentate; surface finely imbricate and rather densely clothed with broad white hairs in the male—pale yellow in the female—which are interrupted by dark areas sparsely clothed with inconspicuous dark hairs as follows: An oblong spot along lateral margin behind the humeri, a diamond-shaped spot behind the scutellum, inclosing a spot of white hairs, a broad transverse band a little behind the middle, with two longitudinal areas extending anteriorly on the median part of each elytron and obliquely backward along suture for a short distance, a crescent-shaped spot on the median part of each elytron at apical fourth, and another oblong spot near apex, reaching from lateral margin

obliquely to near the suture. Abdomen rather densely punctate.

Length, 4.5 millimeters; width, 1.6.

Described from two specimens. The type is from Iligan, Mindanao (*Baker 8329*); paratype from the same locality as the type, without a number.

Sambus fasciatus sp. nov.

Robust, form of the genus *Coraebus*, entirely blue above, elytra marked with transverse bands of silvery white pubescence; beneath greenish blue and rather densely clothed with silvery white pubescence.

Head rather deeply grooved, the groove becoming less distinct on the front, densely punctate on front and vertex, slightly rugose on occiput, rather densely clothed with long white pubescence, becoming nearly obsolete on occiput; antennæ reaching to apical third of pronotum, basal joints green, following joints black, with a slight coppery reflection; clypeal suture distinct; epistoma wide, transverse between the antennæ. Pronotum much wider than long, slightly narrower in front than behind; sides scarcely flattened, regularly arcuate, with lateral margin crenulate and posterior angles broadly rounded; anterior margin deeply, arcuately emarginate, with a slight median lobe and the anterior angles acute; base strongly bisinuate, with a broad median lobe in front of scutellum; lateral carina sinuate and reaching from base to apical fourth; disk rather evenly convex; surface rather densely punctate and concentrically rugose, sparsely clothed with short white hairs, becoming denser toward lateral margin. Scutellum large, triangular, aëneous; surface finely reticulate. Elytra at base about equal in width to pronotum at middle, slightly convex, with the basal depressions shallow and an oblong depression along lateral margin behind the humeri; sides nearly parallel to apical third, then strongly attenuate to tips, which are separately rounded and finely dentate; surface finely imbricate, becoming finely rugose and punctate toward apex, sparsely clothed with short black hairs and marked with a series of short white hairs as follows: An indistinct, broken, transverse band at middle, with a few scattered hairs on basal half, a distinct, wide, transverse band at apical fourth, which is emarginate anteriorly, and with a few scattered hairs at apex. Abdominal segments very densely punctate posteriorly.

Length, 7 millimeters; width, 2.75.

Described from a single specimen from Malinao, Tayabas Province, Luzon (*Baker*).

Sambus luzonicus sp. nov.

Short, nearly parallel, head bright cupreous, pronotum black, with a distinct violaceous reflection; elytra black, basal half irregularly marked with white pubescence, and a transverse band of four rings of white pubescence at apical fourth; beneath shining black, sparsely clothed with very short white pubescence.

Head flat in front, rather deeply grooved on the vertex and occiput, surface strongly, transversely rugose, with a few very short white hairs along the anterior margin; antennæ short, reaching to apical third of pronotum, basal joints coppery, following joints shining black; clypeal suture distinct; epistoma wide, transverse between the antennæ. Pronotum much wider than long, about as wide in front as behind; sides flattened and regularly arcuate, with the lateral margin crenulate; anterior margin bisinuate, with the median lobe broadly rounded; base bisinuate, with a broad median lobe in front of scutellum; lateral carina slightly arcuate, reaching from posterior angles perpendicularly to the middle; disk convex, limited behind at the basal fourth by a widely rounded, transverse depression; surface concentrically rugose on disk and sparsely clothed with recumbent white hairs. Scutellum large, triangular, green; surface finely reticulate. Elytra narrower at base than middle of pronotum, convex, with an oblong depression along lateral margin behind humeri; sides nearly parallel to middle, expanded at apical third, then strongly attenuate to the tips, which are conjointly rounded and finely dentate; surface finely imbricate, sparsely clothed with very short, inconspicuous, brown hairs and irregularly variegated on basal half with broader white hairs, a transverse row of four rings of white pubescence at apical fourth and a few scattered hairs of the same color at apex. Abdomen very finely punctate.

Length, 3.25 millimeters; width, 1.2.

Described from a unique specimen from Mount Banahao, Luzon (*Baker 8331*).

Sambus nigricans sp. nov.

Rather robust, entirely black, elytra marked with irregular patches and transverse bands of silvery white pubescence; beneath black, clothed with short white pubescence.

Head rounded in front, deeply grooved on vertex and occiput, with a broadly rounded depression on front, moderately punctate, very densely granulate, and sparsely clothed with short

white pubescence; antennæ black, reaching to apical fourth of pronotum; clypeal suture not distinct at middle; epistoma wide, transverse between the antennæ. Pronotum much wider than long, slightly narrower in front than behind; sides scarcely flattened, regularly arcuate, with the lateral margin crenulate; anterior margin bisinuate, with the median lobe broadly rounded; base bisinuate, with the median lobe broadly rounded in front of scutellum; lateral carina slightly arcuate, reaching perpendicularly from posterior angle to apical third; disk regularly convex, limited at basal third by a broadly rounded transverse depression, the depression becoming deeper near lateral carina; surface moderately punctate and rather densely clothed with short white hairs. Scutellum large, triangular; surface finely reticulate. Elytral base about equal in width to pronotum at middle, rather convex, with shallow basal depressions, and an oblong depression along lateral margin behind humeri; sides parallel to middle, expanded at apical third, then arcuately attenuate to tips, which are separately rounded and finely dentate; surface finely imbricate at base, becoming finely punctate toward apex, sparsely clothed with inconspicuous hairs of the same color as the surface, and also by a series of broader white hairs, forming designs as follows: On the basal half an irregular longitudinal band on median part and another along suture, these somewhat broken up and connected at basal fourth, a transverse zigzag band at apical fourth connected along suture and lateral margin to a straight transverse band at apical fifth. Abdomen finely punctate and sparsely rugose.

Length, 5 millimeters; width, 1.9.

Described from a single specimen from Malinao, Tayabas Province, Luzon (*Baker*).

Sambus aeneicollis sp. nov.

Rather robust, parallel to apical third; head and pronotum of a bright coppery bronze; elytra black and marked with transverse zigzag bands of silvery white pubescence; beneath black, clothed with short white pubescence.

Head broadly grooved, the groove becoming deeper on vertex and occiput, slightly gibbose on occiput and vertex, finely, densely granulate and sparsely clothed with rather short white and yellow hairs intermixed; antennæ bronzy, short, reaching to apical third of pronotum; clypeal suture distinct; epistoma wide, transverse between the antennæ. Pronotum much wider than long, about as wide in front as behind; sides flattened and

regularly arcuate, with the lateral margin crenulate and the posterior angles broadly rounded; anterior margin slightly bisinuate, without a distinct median lobe; base strongly bisinuate, with a broadly rounded median lobe in front of scutellum; lateral carina strongly arcuate, slightly sinuate anteriorly and reaching from base to near the anterior angles; disk strongly convex anteriorly and limited at the basal fourth by a broadly rounded, transverse depression; surface rather densely punctate and concentrically rugose, sparsely clothed with fine, short, white hairs. Scutellum dark bronzy, large, triangular; surface finely, transversely carinate. Elytra narrower at base than middle of pronotum, rather convex, with shallow basal depressions and a similar depression along suture near apex; sides parallel to apical third, then arcuately attenuate to tips, which are broadly, conjointly rounded and finely dentate; surface finely imbricate, rather densely clothed with short, inconspicuous, dark hairs of the same color as the surface, and marked with broader white hairs as follows: An indistinct elongate series along suture behind scutellum, a double tranverse zigzag row near middle, and a similar, more distinct double row at apical fourth. Abdomen rather densely punctate and finely crenulate.

Length, 4 millimeters; width, 1.6.

Described from a single specimen from Mount Maquiling, Luzon (*Baker 8326*).

Sambus lugubris Saunders.

This species is represented by one specimen from Mount Maquiling, Luzon (*Baker 8327*); one from Baguio, Benguet Province, Luzon (*Baker*); one from Dapitan, Mindanao (*Baker 8328*); three from Davao, Mindanao (*Baker*); and a specimen in the United States National Museum collection labeled "Acc. No. 1130, Bur. Agri., P. I., collected by C. R. Jones," without any definite locality. The Bureau of Agriculture gives Lamao, Bataan Province, Luzon, as the locality for the last specimen.

This species is slightly variable in the coloration of the pubescence. In some specimens the transverse bands are composed of yellow and white hairs intermixed, while in others the pubescence is entirely pale yellow, with all forms of intergrades, but the markings seem to be quite constant on all of the specimens. The males have the entire head bright green and the pronotum of a more bronzy color, while in the females the head and pronotum are of a bright reddish copper color.

Genus **CRYPTODACTYLUS** Deyrolle

Cryptodactylus philippinensis Saunders.

One specimen which I take to be this species was received from Davao, Mindanao (*Baker 8354*).

Genus **TOXOSCELUS** Deyrolle

Toxoscelus rugicollis Saunders.

One specimen from Kobe, Japan, received from Prof. C. F. Baker.

This species was described from central Luzon, and so far the genus has not been reported from Japan. The specimen agrees with the original description in every way with the exception that it is of a dark bronzy color, without any purplish tinge.

Genus **NEOTOXOSCELUS** novum

Form of *Toxoscelus*. Head convex, with a median longitudinal groove interrupted at middle of front, feebly gibbose on vertex; epistoma very narrow and separated from front of head by a deep, sinuate groove; cheeks unarmed; antennal cavities large, oblique, nearly contiguous, and situated a little distance from the inner margin of the eyes. Antennæ short, serrate from the fifth joint; joints one and two robust, the second shorter; third and fourth more slender and about subequal in length; the following joints abruptly and strongly serrate on the inner margin. Eyes large, oval, slightly oblique and more feebly remote behind vertex. Pronotum wider than long, disk convex, with distinct lateral carina; lateral margin smooth. Scutellum visible. Elytra rather flat on the disk; sides sinuate and expanded behind the middle. Prosternum rather flat, with a well-developed frontal lobe, sides not grooved for insertion of antennæ in repose. Mesosternum divided, the lateral branches very short and arcuate between the anterior and median coxæ. Metasternum emarginate in front. Middle coxæ not more widely separated than the anterior ones. Posterior coxæ concave behind, with the lateral margin strongly dilated anteriorly. Femora moderately flat. Tibiæ straight and subcylindrical, the posterior ones ciliate on the posterior margin. Tarsi very short, the first joint not much longer than the second; claws appendiculate at the base.

Genotype, *Neotoxoscelus bakeri* sp. nov.

This genus resembles *Toxoscelus* Deyr. very closely and, superficially, would be placed in that genus. It is, however, easily

separated from *Toxoscelus* in having the pronotum more even and convex, the femora not toothed on the inner side, and by the tibiæ being straight, while in that genus they are very arcuate, leaving a space between them and the femora when closed. From *Metasambus* Kerrem., to which it is also allied, it can be separated by the lateral edge of the pronotum being smooth and not crenulate as in that genus.

Neotoxoscelus bakeri sp. nov.

Elongate, subparallel, feebly convex; above rather shining, dark brown, with a strong violaceous tinge, pubescence on elytra forming irregular designs; beneath piceous, with a strong purplish bronze tinge.

Head cupreous, with the front feebly convex, broadly excavated on vertex and occiput, causing the sides to be feebly gibbose; surface sparsely punctate and vaguely strigose, the intervals finely granulate, glabrous; epistoma broadly emarginate in front; eyes not quite as remote as in *N. luzonicus*. Pronotum one-half wider than long, widest at basal third, slightly wider in front than behind; sides feebly, arcuately rounded to basal third, then suddenly, arcuately narrowed to posterior angles, which are very broadly rounded; anterior margin rather deeply emarginate, with a broadly rounded median lobe, the anterior angles acute; base deeply bisinuate, with a large, broadly rounded lobe in front of scutellum; lateral carina long, sinuous and strongly elevated, distant from the margin and reaching from the apical fifth to the base; surface concave between lateral carina and margin, with a broad, transverse depression along basal third, becoming deeper toward lateral carina, sparsely punctate and feebly strigose, the intervals becoming densely granulate toward lateral margin, sparsely clothed with long, brown and white, recumbent pubescence. Scutellum broadly triangular, surface finely strigose. Elytra at base slightly narrower than widest part of pronotum, slightly flattened on disk, with the basal depressions shallow and a vaguely transverse depression at apical fourth; humeral angles obtusely rounded; sides strongly sinuate at posterior coxæ, broadly expanded just behind middle, then gradually narrowed to tips, which are very broadly, conjointly rounded and finely dentate; surface densely, coarsely punctate and vaguely rugose, sparsely clothed with long brown and white pubescence, the white pubescence forming designs as follows: Each elytron with an elongate series along suture behind scutellum, a large

oblong ring on basal third, a narrow, transverse, zigzag band just behind the middle, and a similar band in the transverse depressed area at apical fourth. Abdomen strongly convex, nearly glabrous, vaguely marked with fine crenulate lines, becoming more distinct on basal segment; prosternum coarsely but not very densely scabrous; prosternal lobe very broad, feebly, arcuately emarginate in front, the margin not elevated, anterior angles rounded; intercoxal process nearly parallel sided to behind coxæ, then arcuately emarginate to apex, which is long and acute; tarsi and claws black; tarsal lamellæ yellowish.

Length, 6.25 millimeters; width, 2.25.

Described from two specimens. The type from Davao, Mindanao (*Baker 8367*); a paratype from the same locality as the type, without any number, is considerably smaller, measuring only 4.5 millimeters in length and 1.5 millimeters in width, and is slightly more cupreous than the type.

Neotoxoscelus luzonicus sp. nov.

Elongate, subparallel, feebly convex; above shining black, with a feeble bluish reflection, pubescence on elytra forming distinct irregular designs; beneath black, shining.

Head with the front strongly convex, broadly excavated on the vertex and occiput, causing the sides to be feebly gibbose; surface finely strigose, the strigæ transverse on the front and becoming concentric on the gibbosities, very sparsely pubescent; epistoma obtusely angulate in front. Pronotum one-half wider than long, widest just behind middle, apex and base about equal in width; sides broadly, arcuately rounded to just behind middle, then abruptly, obliquely narrowed to posterior angles, which are broadly rounded; anterior margin deeply emarginate, with a large, broadly rounded, median lobe, the anterior angles acute; base strongly bisinuate with a broadly rounded lobe in front of scutellum; lateral carina short, arcuate and strongly elevated, distant from the margin and reaching from the apical fourth to just behind the middle; surface concave between lateral carina and margin, and feebly, transversely depressed along basal third, densely, coarsely rugose and sparsely punctate, the punctures becoming coarser along lateral margin, where the surface is feebly reticulate, sparsely clothed with rather long, black pubescence. Scutellum broadly triangular, surface finely strigose-granulate. Elytra at base distinctly narrower than widest part of pronotum, feebly flattened on disk, basal depressions shallow; humeral angles obtusely rounded; sides

nearly parallel to just behind the middle, where they are strongly, broadly expanded, then gradually narrowed to tips, which are conjointly rounded, but not as broadly as in *N. bakeri,* and feebly dentate; surface densely, rather finely punctate, and feebly rugose at base, sparsely clothed with long black and white pubescence, the white pubescence forming designs as follows: Each elytron with an oblong circle at middle, connected posteriorly to a transverse, irregular series, and a narrow transverse zigzag band at apical fifth. Abdomen strongly convex, nearly glabrous, vaguely marked with fine crenulate lines; prosternum densely, roughly scabrous; prosternal lobe widely, arcuately emarginate in front, with the margin elevated; intercoxal process gradually narrowed behind coxæ, the apex rather acute; tarsi and claws black; tarsal lamellæ dark brown.

Length, 6 millimeters; width, 2.1.

Described from one specimen from Los Baños, Luzon (*Baker*).

This species is closely allied to *N. bakeri,* but differs from it in the coloration and arrangement of the white pubescent spaces on the elytra, tips of the elytron not as broadly rounded, and by the very short lateral carina on pronotum.

Genus **PARATRACHYS** Saunders

Paratrachys pilifrons Kerremans.

This genus has not been reported from the Philippines before, but one specimen which I take for Kerremans' *pilifrons* was received from Baguio, Benguet, Luzon (*Baker 8345*).

This species was originally described from Sumatra.

Genus **TRACHYS** Fabricius

Key to the species.[9]

1. Elytra with longitudinal carina along lateral margin ..... 2.
   Elytra without longitudinal carina along lateral margin ..... 7.
2. Epistoma narrow between antennæ, not transverse ..... 3.
   Epistoma wide between the antennæ, transverse ..... 4.
3. Surface above glabrous ..... T. glabra sp. nov.
   Surface above pubescent ..... T. palawana Kerrem.
4. Head with deep pit above base of antennæ ..... 5.
   Head without deep pit above base of antennæ ..... T. metallica sp. nov.
5. Surface above unicolored ..... T. philippinensis sp. nov.
   Surface above bicolored ..... 6.

[9] The following species of *Trachys* reported from the Philippines have not been seen by me: *Trachys bakeri* Kerrem., *T. cornuta* Kerrem., *T. dubia* Saund., *T. formosana* Kerrem., *T. fraterna* Kerrem., *T. luzonica* Kerrem., and *T. rufescens* Kerrem.

6. Sides of pronotum widely flattened; dense yellow pubescence of elytra extending along suture and forming two oblong fascia near apex. T. cuneiformis sp. nov.
   Sides of pronotum not distinctly flattened; dense yellow pubescence of elytra confined to apical fourth but not forming distinct fascia. T. mindanaoensis sp. nov.
7. Intercoxal process wider than long, apex truncate.... T. picta sp. nov.
   Intercoxal process longer than wide, apex rounded..... 8.
8. Epistoma narrow between antennæ, not transverse..... 9.
   Epistoma wide between antennæ, transverse..... 10.
9. Form cuneiform; surface unicolored; tarsal joints and lamellæ yellow. T. piceiventris sp. nov.
   Form ovate; surface bicolored; tarsal joints black, lamellæ paler. T. cupripyga Deyr.
10. Epistoma arcuately emarginate in front..... 11.
    Epistoma rectangularly emarginate in front..... 14.
11. Surface above glabrous..... T. cyanipennis sp. nov.
    Surface above pubescent..... 12.
12. Color above blue..... T. princeps Saund.
    Color above dark bronze..... 13.
13. Broadly ovate; elytra with a distinct U-shaped design. T. lunata sp. nov.
    Narrowly ovate; elytra without a distinct U-shaped design. T. marmorata sp. nov.
14. Form rather robust; tarsal joints black; pubescence of elytra consisting of white and yellow hairs intermixed..... T. ovata sp. nov.
    Form more slender; tarsal joints yellow; pubescence of elytra consisting of white and dark brown hairs intermixed. T. viridula Kerrem.

Trachys glabra sp. nov.

Ovate, slightly convex, rounded posteriorly, uniformly black above and beneath, glabrous.

Head narrow, with the front slightly concave between the eyes, with a feeble, median, longitudinal groove, becoming broader anteriorly; surface with a small puncture near base of antennæ, granulose and sparsely marked with small circles containing a minute puncture at middle; eyes rather strongly margined on the inner side; epistoma very narrow, not transverse, longitudinally grooved, the anterior margin not distinctly emarginate; clypeal suture not visible; antennæ nearly contiguous. Pronotum short, two and one-half times as wide as long, much narrower in front than behind; surface rather densely marked with distinct circles, intervals between the circles smooth, except along lateral margin, where they are finely granulose; anterior margin deeply, arcuately emarginate, the angles acute and extending forward on a line with the front of head; sides broadly flattened, strongly arcuate to middle, then obliquely widened to

the posterior angles, which are rather acute; base nearly truncate to the median lobe, which is broadly rounded in front of the scutellum. Scutellum small, triangular. Elytra a little wider than pronotum at base; sides slightly flattened, strongly arcuate to basal fourth, then arcuately attenuate to the tips, which are conjointly, broadly rounded; humeri not prominent; surface with a distinct, arcuate, lateral carina reaching from humerus to apical margin, with rows of fine punctures, the sutural row widely arcuate behind the scutellum, forming a moderately wide smooth area, and with a rather deep, elongate depression along lateral margin behind the humeri. Beneath flattened; abdomen very finely granulate and with densely placed, elongate, circular marks; prosternum distinctly divided into two parts, the anterior part slightly bent downward, the front margin truncate but not distinctly elevated; intercoxal process flat, transverse, sides nearly parallel to posterior angles, which are rounded, apex truncate; mesosternum with the anterior margin truncate; tarsi and claws black; tarsal lamellæ pale.

Length, 2 millimeters; width, 1.35.

One specimen from Davao, Mindanao (*Baker*).

Trachys palawana Kerremans.

Two specimens of this species received from Puerto Princesa, Palawan (one is *Baker 8342*, the other without a number).

Trachys metallica sp. nov.

Elongate, slightly convex, very much enlarged anteriorly; above dark bronze, shining pubescent; beneath shining black.

Head with the front slightly concave between the eyes, median longitudinal groove indistinct; surface nearly smooth, indistinctly marked with small circles, and very sparsely clothed with fine, yellow, recumbent hairs; epistoma wide, not elevated; clypeal suture not distinct; anterior margin of epistoma broadly, arcuately emarginate, the anterior angles acute and projecting beneath base of antennæ, which are widely separated; eyes with the inner side strongly margined. Pronotum short, nearly three and one-half times as wide as long, much narrower in front than behind; surface with a small oblong depression near each posterior angle, densely marked with distinct circles, having a distinct puncture in the middle, and sparsely clothed with fine, yellow, recumbent pubescence; anterior margin rather deeply, arcuately emarginate, front angles acute; sides obliquely arcuate; base slightly bisinuate, the median lobe broadly angulate

and slightly emarginate in front of the scutellum. Scutellum rather large, triangular. Elytra a little wider than pronotum at base, slightly sinuate near posterior coxæ, then strongly attenuate to the tips, which are conjointly, broadly rounded; humeri not prominent; surface with a distinct straight lateral carina, reaching from posterior part of humerus to near the apical margin, finely punctate and slightly rugose, with a shallow broad depression along base and a deeper one along lateral margin behind the humerus, very sparsely clothed with short, yellow, recumbent hairs, becoming a little denser along lateral margin, and forming three inconspicuous, transverse bands which are interrupted at the suture; the first at about the middle, the second at apical third, and the last one at the apex. Beneath convex; abdomen densely marked with semicircular lines, in the middle of which is a small puncture; intervals very finely granulate, with a few extremely short white hairs; prosternum distinctly divided into two parts, the anterior part bent downward, with the front margin truncate and slightly elevated; intercoxal process transverse, flat, distinctly narrower in front than behind, apex truncate, the angles rounded; mesosternum with the anterior margin truncate; tarsi and claws black.

Length, 3.25 millimeters; width, 2.

One specimen from Zamboanga, Mindanao (*Baker*).

Trachys philippinensis sp. nov.

Elongate, convex, enlarged anteriorly; above of a bright bronzy color, pubescent; beneath black, with a slight metallic reflection.

Head with the front rather deeply concave between the eyes, median longitudinal groove not distinctly marked; surface nearly smooth, punctuation indistinct except under a high-power lens, with a deep puncture near base of antennæ and a widely angulated median depression in front of clypeal suture, sparsely clothed with short, light yellow, recumbent hairs; eyes rather strongly margined on the inner side; epistoma wide, elevated, finely, transversely strigose, anterior margin truncate, the angles acute and extending beneath base of antennæ, which are rather widely separated; clypeal suture distinct, subtruncate. Pronotum short, a little more than three times as wide as long, narrower in front than behind; surface rather densely marked with inconspicuous circles, becoming smoother on the disk, sparsely clothed with short, light yellow, recumbent pubescence; anterior margin deeply, arcuately emarginate, the angles acute;

sides obliquely arcuate; base bisinuate, with a broadly rounded median lobe in front of the scutellum. Scutellum small, triangular. Elytra as wide as pronotum at base, obliquely sinuate to posterior coxæ, then strongly attenuate to near tips, which are conjointly, broadly rounded; humeri not prominent; surface with an arcuate lateral carina, reaching from near the humerus to just in front of the apical margin, finely punctate and rather strongly rugose, with a shallow depression along the base and a similar one along lateral margin behind the humerus, rather sparsely clothed with pale and golden yellow pubescence, the pale hairs forming three inconspicuous, transverse, somewhat irregular designs as follows: The first near middle, the second at apical third, and the third one near the apex. Beneath convex; abdomen densely marked with semicircular lines, in the middle of which is a small puncture, intervals distinctly granulose and with a few indistinct white hairs; prosternum divided into two parts, the anterior part flat, with the front margin distinctly margined and a transverse costa near and parallel to it; intercoxal process transverse, flat, narrower in front than behind, sides margined, apex truncate, with the angles rounded; mesosternum with the anterior margin truncate; tarsi and claws black; tarsal lamellæ dark brown.

Length, 3 millimeters; width, 1.75.

One specimen from Mount Maquiling, Luzon (*Baker 8338*).

Trachys cuneiformis sp. nov.

Cuneiform, slightly convex, very much enlarged anteriorly, head, pronotum, suture, and posterior third of elytra bronzy, anterior two-thirds of elytra, except suture, dark blue, with a violaceous reflection, pubescent; beneath black, with a metallic reflection.

Head with the front deeply concave between the eyes, median longitudinal groove slightly marked from occiput to near middle; surface with a deep, round puncture in front of suture near base of antennæ, sparsely marked with indistinct circles, from which arises a short, yellow, recumbent hair, the circles denser on the occiput and near frontal suture; eyes very strongly margined on the inner side; epistoma wide, finely, transversely strigose, anterior margin truncate, the anterior angles acute and extending around base of antennæ, which are widely separated; clypeal suture distinct, truncate. Pronotum short, three times as wide as long, much narrower in front than behind; surface densely marked with distinct circles, becoming less distinct on

the elevated part of disk, sparsely clothed with moderately long, whitish and golden yellow, recumbent pubescence; sides flattened, becoming more broadly so posteriorly, and extending along posterior margin, forming a broadly triangular elevation on the anterior median part, and with a small puncture near the posterior angles; anterior margin deeply, arcuately emarginate, with the angles acute; sides strongly, obliquely arcuate; base bisinuate, with a large, round, median lobe, slightly truncate in front of the scutellum. Scutellum rather large, broadly triangular. Elytra as wide as pronotum at base, slightly sinuate near posterior coxæ, strongly attenuate to the tips, which are conjointly, broadly rounded; humeri rather prominent; surface with a distinct arcuate carina, reaching from humeral angles to apical margin, finely, rather densely punctate and moderately rugose, with a deep linear depression along base and a deeply concave depression between the lateral carina and lateral margin, reaching from humeral angle to a little beyond the posterior coxæ, sparsely clothed on the violaceous parts with short, dark, recumbent pubescence, the pubescence more yellow on the cupreous part along suture, and becoming much denser and more golden yellow on the entire apical third, which is margined anteriorly by a transverse zigzag series of white hairs, the apical part with a small, inconspicuous, round, median spot on each elytron, composed of darker pubescence. Beneath rather convex; abdomen densely marked with circles, in the middle of which is a small puncture; intervals finely granulose, with a few, inconspicuous, white hairs. Prosternum distinctly divided into two parts, the anterior portion bent downward, with the front margin broadly arcuate and feebly margined; intercoxal process transverse, flat, much narrower in front than behind, apex truncate, with the angles rounded; mesosternum with the anterior margin truncate; tarsi and claws black; tarsal lamellæ brownish.

Length, 3 millimeters; width, 1.75.

Described from two specimens. The type from Davao, Mindanao (*Baker 8339*); paratype from the same locality without a number.

Trachys mindanaoensis sp. nov.

Elongate, slightly convex, attenuate posteriorly; head and pronotum of a dark bronze color; elytra dark violaceous blue, becoming slightly bronzy posteriorly, pubescent; beneath black, with a metallic reflection.

Head with the front slightly concave between the eyes, with a median longitudinal groove reaching from apex to middle; surface rather densely marked with small circles, from the center of which arises a very fine, light yellow, recumbent hair, and with a deep oblong puncture in front of suture near base of antennæ; eyes slightly margined on the inner side; epistoma wide, slightly elevated, finely, transversely strigose, anterior margin truncate, the angles acute and protruding around base of antennæ, which are widely separated; clypeal suture distinct, subtruncate. Pronotum short, three times as wide as long, much narrower in front than behind; surface with rather densely placed circular marks, becoming less dense on the disk, sparsely clothed with fine, light yellow, recumbent hairs; anterior margin deeply, arcuately emarginate, the angles rather acute; sides strongly, obliquely arcuate to the posterior angles, which are acute; base bisinuate, with a broadly rounded median lobe in front of scutellum. Scutellum small, triangular. Elytra as wide as pronotum at base, slightly sinuate near posterior coxæ, then obliquely arcuate to near tips, which are conjointly rounded; humeri not prominent; surface with a distinct lateral carina, reaching from the humeri to near the apex, rather densely, finely punctate, broadly depressed along base near humeri and with a more elongate depression along lateral margin just behind humeri, sparsely clothed on the anterior violaceous part with short, reddish brown, recumbent hairs, becoming much denser and more golden yellow on the apical third. Beneath convex, abdomen densely marked with semicircular lines, the middle of each with a fine puncture; intervals finely granulate, with a few, inconspicuous, white hairs; prosternum divided into two parts, the anterior part slightly bent downward, with the front margin truncate and distinctly margined; intercoxal process transverse, flat, narrower in front than behind, apex truncate, with the angles slightly rounded; mesosternum with the anterior margin truncate; tarsi and claws black.

Length, 3 millimeters; width, 1.8.

Described from two specimens. The type from Iligan, Mindanao (*Baker 8340*); a paratype from Davao, Mindanao (*Baker*).

Trachys picta sp. nov.

Oblong-ovate, convex, slightly enlarged anteriorly, rounded posteriorly; above bronzy black, pubescent; beneath black, with a metallic reflection.

Head with the front slightly concave between the eyes, with a median longitudinal groove reaching from apex to middle; surface with a deep puncture near base of antennæ, rather densely marked with small circles, from the center of which arises a short, yellow, recumbent hair and with a small median smooth area; eyes with the inner side strongly margined; epistoma wide, elevated, anterior margin widely, arcuately emarginate, the angles acute and extending under base of antennæ, which are widely separated; clypeal suture distinct. Pronotum short, about four times as wide as long, narrower in front than behind; surface densely marked with circles, similar to that of the head, densely clothed with white, yellow, and reddish brown recumbent pubescence intermixed; anterior margin deeply, arcuately emarginate, with the angles acute; sides oblique and slightly arcuate; base bisinuate, with a broadly rounded median lobe in front of scutellum. Scutellum small, triangular. Elytra as wide as pronotum at base, gradually attenuate to the posterior third, then arcuate to the tips, which are conjointly, broadly rounded; humeri not very prominent; surface without lateral carina, densely punctate and rather strongly rugose, broadly depressed along base near humeri, and densely clothed with short white, yellow, and dark brown recumbent pubescence, forming irregular designs, the designs becoming more transversely zigzag toward the apex, with a distinctly marked inverted W, composed of white pubescence just in front of apex. Beneath convex; abdomen coarsely and densely marked with semicircular lines, in the middle of which is a small puncture, finely granulate and sparsely clothed with distinct whitish recumbent hairs; prosternum distinctly divided into two parts, the anterior part bent downward, with the front margin broadly arcuate and distinctly margined; intercoxal process transverse, flat, narrower in front than behind, sides distinctly margined and slightly arcuate to the posterior angles, which are rounded, apex truncate; mesosternum with the anterior margin truncate; tarsi and claws black.

Length, 4 millimeters; width, 2.4.

One specimen from Dapitan, Mindanao (*Baker*).

Trachys piceiventris sp. nov.

Elongate, convex, slightly enlarged anteriorly, feebly rounded posteriorly; uniform piceous above, with a slight bronzy reflection, pubescent; beneath piceous.

Head with the front deeply concave between the eyes, without

median longitudinal groove; surface smooth and rather densely clothed with long, golden, recumbent pubescence; eyes strongly margined on the inner side; epistoma narrow, not transverse, slightly elevated, anterior margin deeply, arcuately emarginate, the anterior angles not well defined; antennæ narrowly separated; clypeal suture distinct and strongly angulate. Pronotum short. three times as wide as long, slightly narrower in front than behind; surface densely marked with distinct circles, from the center of which arises a rather erect pale yellow hair; anterior margin rather deeply, arcuately emarginate, the angles rather obtuse; sides slightly, obliquely arcuate, base bisinuate, with a broadly rounded median lobe in front of scutellum. Scutellum very small, triangular. Elytra a little wider than pronotum at base, slightly sinuate to posterior coxæ, then obliquely arcuate to the tips, which are conjointly rounded, humeri not prominent; surface without lateral carina, finely and rather densely punctate, with a wide, shallow depression along base and a similar one along lateral margin behind humerus, the entire anterior two-thirds rather densely clothed with short, very fine, semierect, piceous hairs, with the exception of a few scattered pale yellow hairs near scutellum, the entire apical third densely clothed with pale yellow recumbent hairs, this space with the anterior margin angulate, and with a round dark spot on the middle of each elytron at the apical fourth. Beneath convex; abdomen rather densely but not distinctly marked with semicircular lines and finely granulate, sparsely clothed with minute white hairs; prosternum not distinctly divided into two parts, anterior margin truncate and distinctly margined; intercoxal process elongate, flat, sides feebly, arcuately concave, apex slightly expanded and broadly rounded; mesosternum with the anterior margin deeply, arcuately emarginate; tarsi and lamellæ yellow; claws black.

Length, 2.75 millimeters; width, 1.5.

One specimen from Puerto Princesa, Palawan (*Baker*).

Trachys cupripyga Deyrolle.

One specimen which I take for this species was received from Puerto Princesa, Palawan (*Baker 8344*).

Trachys cyanipennis sp. nov.

Elongate, strongly convex, rounded posteriorly, head and pronotum bronzy black; elytra bright cyaneous, glabrous; beneath black, rather shining.

Head with the front broadly concave between the eyes, without distinct median groove; surface with a deep puncture near base of antennæ and indistinctly marked with small circles, glabrous; eyes rather strongly margined on the inner side; epistoma wide, flat, anterior margin very deeply, arcuately emarginate, anterior angles rather broad; antennæ widely separated; clypeal suture not distinct. Pronotum strongly convex, short, two and one-half times as wide as long, slightly narrower in front than behind; surface nearly smooth, rather densely marked with nearly obsolete circles, similar to those of the head; anterior margin arcuately emarginate, the angles rather obtuse; sides slightly flattened, arcuate to the middle, then obliquely widened to the posterior angles, which are nearly rectangular; base bisinuate, with a broadly rounded median lobe in front of the scutellum. Scutellum very small, triangular. Elytra strongly convex, without any conspicuous depressions, slightly wider than pronotum at base, parallel to near middle, then strongly, arcuately attenuate to the tips, which are conjointly, narrowly rounded; humeri not prominent; surface without lateral carina, densely, irregularly, and coarsely punctate. Beneath convex; abdomen rather densely marked with semicircular lines and very finely granulate, glabrous; prosternum divided into parts, anterior margin truncate, sharply margined; intercoxal process elevated, elongate, wider behind than in front, sides slightly margined, apex rounded; mesosternum with the anterior margin deeply, arcuately emarginate; tarsi and claws black.

Length, 2.9 millimeters; width, 1.7.

One specimen from Tacloban, Leyte (*Baker 8343*).

Trachys lunata sp. nov.

Ovate, moderately convex, rounded posteriorly; above of a dark bronzy color, pubescent; beneath black, shining.

Head with the front slightly concave between the eyes, with a distinct, median, longitudinal groove reaching from apex to middle; surface smooth, with a small round puncture near base of antennæ, rather densely marked with indistinct circles, and sparsely clothed with reddish yellow, recumbent pubescence; eyes slightly margined on the inner side; epistoma wide, smooth, and not elevated, anterior margin rather deeply, arcuately emarginate, angles rather broad; antennæ widely separated; clypeal suture not visible. Pronotum short, three times as

wide as long, much narrower in front than behind; surface densely marked with circles, becoming less distinct on the anterior part of the disk, rather densely clothed with short, white and golden yellow, recumbent hairs intermixed, giving it a variegated appearance; anterior margin slightly, arcuately emarginate, the angles obtuse; sides finely crenulate and slightly, obliquely arcuate; base strongly bisinuate, with a widely angulated median lobe in front of the scutellum. Scutellum very small, triangular. Elytra a little wider than pronotum at base, slightly sinuate near the posterior coxæ, then strongly arcuate to the tips, which are conjointly, widely rounded and slightly gibbose; humeri not prominent; surface without lateral carina, finely, densely punctate and rather strongly rugose, with a wide, shallow depression along base and a similar one along lateral margin near the posterior coxæ, uniformly, densely clothed with short, white and reddish yellow, recumbent pubescence, except a large U-shaped design on the disk, composed of very slender, dense, black hairs, the design reaching from the base to the apical third. Beneath convex; abdomen densely reticulate and finely granulate, sparsely clothed with inconspicuous white hairs; prosternum not distinctly divided into two parts, anterior margin truncate and distinctly margined; intercoxal process elongate, flat, nearly parallel, sides distinctly margined, apex broadly rounded; mesosternum with the anterior margin arcuately emarginate; tarsi and lamellæ yellow; claws black.

Length, 4 millimeters; width, 2.25.

One specimen from Davao, Mindanao (*Baker 8341*).

Trachys princeps Saunders.

This beautiful species is represented in the United States National Museum collection by two specimens; one labeled "Acc. No. 1710 Bur. Agri., P. I., collected by C. R. Jones," without any definite locality, and the other one labeled "Lamao, Luzon, P. I., III–VI, 11, C. V. Piper, collector." The Bureau of Agriculture gives Lamao as the locality for the specimen collected by Jones.

Trachys marmorata sp. nov.

Oblong-ovate, slightly convex, rounded posteriorly, head of a bright bronzy color, pronotum and elytra piceous, the former with bronzy reflections, pubescent; beneath shining black, with metallic reflections.

Head with the front rather deeply concave between the eyes, without distinct median longitudinal groove, but with a rather deep, wide, median depression, reaching from middle to clypeal suture; surface with a deep, round puncture in front of suture near base of antennæ, very finely punctate, and densely clothed with long, golden yellow, recumbent pubescence; eyes rather strongly margined on the inner side; epistoma wide, slightly elevated, finely, transversely strigose, anterior margin very deeply, arcuately emarginate, the angles rather broad; antennæ widely separated; clypeal suture not very distinct, broadly arcuate. Pronotum short, nearly three and one-half times as wide as long, narrower in front than behind; surface densely marked with circles, becoming less distinct on disk, clothed with white and dark reddish brown, recumbent hairs, arranged in distinct, irregular series over the entire surface, the darker hairs becoming inconspicuous on the dark areas; anterior margin slightly, arcuately emarginate, anterior angles obtuse; sides slightly flattened, finely crenulate and feebly, obliquely arcuate; base bisinuate, with a broadly rounded median lobe in front of the scutellum. Scutellum very small, triangular. Elytra a little wider than pronotum at base, strongly attenuate to near the tips, which are conjointly rounded and slightly gibbose; humeri not prominent, longitudinally carinate in front; surface without lateral carina, densely, finely punctate, with a wide, shallow depression along base and a somewhat deeper one along the lateral margin below the humerus, rather densely clothed with long, very slender, black hairs, intermixed with broader, silvery white, recumbent ones, the white hairs forming irregular designs on the anterior half and a double transverse zigzag row at the apical third. Beneath rather convex; abdomen densely reticulate and very finely granulate, with a few white recumbent hairs; prosternum not divided, anterior margin truncate and slightly elevated; intercoxal process elongate, flat, elevated, narrower in front than behind, sides distinctly margined, apex dilated and broadly rounded; mesosternum with the anterior margin arcuately emarginate; tarsi reddish brown, with the lamellæ paler; claws black.

Length, 3.65 millimeters; width, 2.

Described from one specimen in the United States National Museum collection, collected in Mindanao, May, 1914 (*C. V. Piper*).

Trachys ovata sp. nov.

Ovate, moderately convex, rounded posteriorly; head and pronotum dark bronzy; beneath black; elytra piceous with bronzy reflection.

Head with the front rather deeply concave between the eyes, with an indistinct median longitudinal groove reaching from apex to clypeal suture; surface with a small round puncture near base of antennæ, rather densely marked with indistinct circles and clothed with short, white and yellow, recumbent hairs intermixed; eyes rather strongly margined on the inner side; epistoma wide, flat, finely, transversely strigose, anterior margin rectangularly emarginate, the angles rather broad; antennæ rather widely separated; clypeal suture indistinct. Pronotum short, three times as wide as long, slightly narrower in front than behind; surface densely marked with indistinct circles, and clothed with short, white and golden yellow, recumbent hairs intermixed; anterior margin slightly, arcuately emarginate, the angles obtuse; sides finely crenulate, oblique and slightly arcuate; base bisinuate, with a broadly rounded median lobe in front of scutellum. Scutellum small, triangular. Elytra a little wider than pronotum at base, sligtly sinuate to posterior coxæ, then strongly, arcuately attenuate to tips, which are conjointly rounded; humeri moderately prominent; surface without lateral carina, very finely and densely punctate, with a broad, shallow depression at base and a deeper one along lateral margin behind the humerus, rather densely clothed with short, silvery white and golden yellow, recumbent pubescence, the white hairs forming irregular designs on the basal half, and two distinct zigzag lines, the first just behind the middle and the other one at the apical fourth. Beneath rather convex, abdomen marked with semicircular lines and very finely granulate, sparsely clothed with short, recumbent, white hairs; prosternum not distinctly divided into two parts, anterior margin truncate and margined; intercoxal process elongate, wider behind than in front, sides slightly margined, apex rounded; mesosternum with the anterior margin arcuately emarginate; tarsi and claws black; tarsal lamellæ paler.

Length, 2.5 millimeters; width, 1.5.

Described from three specimens in the United States National Museum collection labeled "Acc. No. 996, Bur. Agri., P. I., collected by C. R. Jones," without a definite locality. The Bureau of Agri-

culture gives Lamao, Bataan Province, Luzon, as the locality for this number.

This species is closely allied to *T. viridula* Kerrem., but can be at once distinguished from that species by the tarsal joints being black instead of yellow; the pubescence on elytra consisting of white and yellow hairs, while in *viridula* they are white and dark brown, and also by being a little more robust.

Trachys viridula Kerremans.

This species is represented in the United States National Museum collection by three specimens labeled "Acc. No. 996, Bur. Agri., P. I., collected by C. R. Jones," without a definite locality. The Bureau of Agriculture gives Lamao, Bataan Province, Luzon, as the locality for this number. Another specimen from Mount Maquiling, Luzon (*Baker*), does not differ from the ones in the collection.

Genus **ANTHAXOMORPHUS** Deyrolle

Anthaxomorphus philippinensis sp. nov.

Oblong, rather convex, dark brown, with slight coppery reflection, head, sides of pronotum and elytra greenish bronze, shining; beneath black.

Head widely grooved between the eyes, the groove becoming more widely flattened in front of epistoma; front divided into two parts, which are round on the vertex, finely granulate, and finely, irregularly rugose; antennal cavities large; epistoma broadly triangular, anterior margin broadly, arcuately concave, with the angles very acute. Pronotum very transverse, more than twice as wide as long; front narrower than base; sides finely crenulate, arcuately rounded from base to just behind the middle, then more rapidly narrowed to front angles, which are obtuse; anterior margin sinuate, with a widely rounded median lobe; base strongly bisinuate, with a very large, widely rounded lobe in front of scutellum; surface rather evenly convex, with a slight depression along the base on each side of the median lobe, very finely punctate and transversely rugose over entire surface. Scutellum small, broadly triangular. Elytra equal in width to widest part of pronotum; humeral angles broadly rounded; sides finely dentate, strongly sinuate near middle, then broadly rounded to the tips, which are conjointly rounded; humeri not prominent, back of which is a rather deep depression along the anterior margin of elytra, extending obliquely toward the tips, the depression becoming nearly obsolete behind middle,

but having the rugæ a little finer; very finely punctate and irregularly rugose over entire surface. Beneath shining black, sparsely, finely punctate, each abdominal segment with two large punctures along anterior margin; prosternum broadly rounded at apex, the median part rather densely covered with short, acute tubercles; legs, tarsi, and tarsal claws black; tarsal lamellæ light brown.

Length, 3.5 millimeters; width, 2.

The type is from Malinao, Tayabas Province, Luzon (*Baker*). A specimen from Dapitan, Mindanao (*Baker*), differs from the type in being darker in color, head bluish on anterior half, becoming greenish toward vertex, a little more elongated in form, and by being slightly smaller, measuring 3.35 millimeters in length and 1.75 millimeters in width.

Genus APHANISTICUS Latreille

Key to the species.[10]

1. Elytra with longitudinal costæ ..... 2.
   Elytra without longitudinal costæ ..... 3.
2. Prothorax broadly cordate; elytral intervals not distinctly, transversely costate; scutellum visible ..... A. costipennis sp. nov.
   Prothorax transverse, sides evenly arcuate; elytral intervals on anterior part of disk transversely costate; scutellum invisible. A. bakeri sp. nov.
3. Head deeply excavated between the eyes ..... 4.
   Head feebly excavated between the eyes ..... 5.
4. Pronotum distinctly, transversely grooved at middle .. A. excavatus sp. nov.
   Pronotum not transversely grooved at middle ..... A. piceipennis sp. nov.
5. Pronotum with a deep fovea near posterior angles ..... 6.
   Pronotum without a deep fovea near posterior angles ..... 7.
6. Head rounded in front ..... A. mindanaoensis sp. nov.
   Head narrowly, deeply emarginate in front ..... A. foveicollis sp. nov.
7. Form slender; prothorax widest in front of middle. A. unicolor sp. nov.
   Form robust; prothorax widest at middle ..... A. trachyformis sp. nov.

Aphanisticus costipennis sp. nov.

Elongate, depressed, uniformly black, shining.

Head elongate, slightly narrower posteriorly, much narrower than the prothorax; front rather widely and very deeply excavated between the eyes, the lateral sides of excavation subparallel; eyes with the inner side abruptly margined and placed at the extreme lateral part of the excavation; surface finely,

[10] I have been unable to examine specimens of either *A. bodongi* Kerrem. or *A. nigroaeneus* Kerrem., both of which are reported from the Philippines.

densely granulate, with a few large punctures intermixed on the vertex. Pronotum broadly cordate, much wider than long; sides very finely crenulate, broadly, arcuately rounded posteriorly to the middle, then obliquely narrowing to posterior angles, which are obtuse; anterior margin broadly, arcuately emarginate; base bisinuate, with a rounded median lobe, somewhat elevated, in front of the scutellum; disk convex, the convexity formed by two abrupt transverse elevations, the anterior one consisting of two semicircular swellings joined together at the middle, with the tips pointing backward, the posterior elevation consisting of a broadly triangular swelling, joined anteriorly to the front elevation on the median line and posteriorly to the median lobe in front of scutellum; surface finely, densely granulate, the granulation becoming somewhat finer on the elevations. Elytra distinctly wider than prothorax at base; humeral angles obtusely angulate; sides strongly sinuate behind the humeri to near the middle, then obliquely narrowed to the tips, which are separately, broadly rounded and very finely dentate; on the middle of each elytron a distinct sinuate median costa reaching from base to near apex, then following the outline of elytral tip and joining the suture, which is strongly elevated on the posterior half, an indistinct subsutural costa, subequally distant between the median costa and suture, becoming obsolete just behind the middle, and another indistinct costa parallel to the anterior margin, beginning just back of the lateral depression and joining the median costa near the apex; humeri with a distinct oblique costa, limited posteriorly by a rather deep depression reaching from the median costa to the anterior margin; intervals strongly, densely granulate, with a few indistinct, irregular, transverse rugæ between the costæ. Beneath shining black, surface of abdomen marked with large oblong circles; anterior margin of prosternum sinuate; tarsi and claws black; tarsal lamellæ yellow.

Length, 4 millimeters; width, 1.25.

One specimen from Malinao, Tayabas Province, Luzon (*Baker*).

Aphanisticus bakeri sp. nov.

Elongate, subconvex, uniformly shining black.

Head elongate, slightly wider posteriorly, distinctly narrower than the prothorax; front rather widely and deeply excavated between the eyes, lateral sides of excavation more obliquely concave than in *costipennis*, subparallel; eyes with the inner side

abruptly margined and placed at the extreme lateral part of the excavation; surface finely, densely granulate, with a few large punctures intermixed on the vertex. Pronotum transverse, much wider than long; sides very finely crenulate, broadly, evenly arcuate, widest at middle; anterior margin sinuate, with a large median lobe, the anterior angles rather acute; base bisinuate, with a large, acutely triangular lobe at middle; disk convex, the convexity formed by two abrupt, transverse elevations, separated by a very deep transverse groove, which extends around the ends of the posterior elevation, then extending along the base toward median lobe, the anterior elevation placed at middle of pronotum and abruptly truncate posteriorly, the posterior one not quite as long, with the top evenly rounded; along the anterior margin on the median lobe are two abruptly elevated teeth, pointing backward; surface finely, densely granulate, the granulation becoming somewhat finer on the elevations. Scutellum invisible. Elytra wider than prothorax at base; humeral angles obtusely angulate; sides strongly sinuate behind the humeri and rather abruptly expanded just behind middle, then strongly, obliquely narrowed to tips, which are separately rounded and finely dentate; median costa strongly elevated from base to apex, subsutural costa slightly nearer the median costa than the suture, strongly elevated, becoming suddenly obsolete at middle of elytron, an indistinct costa parallel to the lateral margin, begining at the inflated portion, meeting the median costa at apex and extending around the tips of elytron and joining the suture, which is strongly elevated for its entire length; humeri strongly gibbous, with a distinct lateral costa, limited posteriorly by a very deep depression, reaching from median costa to internal margin and posteriorly to the inflated lateral part of the elytron; intervals very finely and densely granulate, with numerous transverse rugæ between the costæ on the anterior half of the elytron, the rugæ as well marked as the costæ. Beneath shining black, surface of abdomen marked with large oblong circles; anterior margin of prosternum truncate; tarsi and claws black; tarsal lamellæ yellow.

Length, 3.25 millimeters; width, 1.

One specimen from Davao, Mindanao (*Baker 8333*).

Aphanisticus excavatus sp. nov.

Elongate, rather convex, head and prothorax dark bronzy, elytra black, shining.

Head elongate, slightly wider posteriorly, much narrower than the prothorax; front rather widely and very deeply excavated between the eyes, the lateral sides of the excavation parallel; eyes with the inner side sharply margined, but not as abruptly as in *costipennis*, placed at the extreme lateral part of the excavation; surface very finely granulate, shining, with a few large, round punctures intermixed, especially in the excavation between the eyes. Pronotum somewhat broadly cordate, much wider than long; sides indistinctly crenulate, broadly, arcuately rounded posteriorly to a little behind the middle, then obliquely narrowing to the posterior angles, which are obtuse; anterior margin broadly, arcuately emarginate; base bisinuate, with a widely rounded median lobe in front of scutellum; disk rather abruptly convex, with the sides widely flattened, the convexity with a shallow groove just back of the middle and another angulate, somewhat deeper groove, along the anterior margin; surface finely, densely granulate. Scutellum very small, triangular. Elytra a little wider than prothorax at base; humeral angles strongly angulate; sides slightly sinuate behind the humeri, strongly, obliquely narrowed from middle to the tips, which are separately rounded; humeri not prominent, limited posteriorly by a depression along the lateral edge, causing the side margin to be slightly flattened along the anterior third; suture gradually elevated on the posterior fourth; surface without costæ, very finely granulate and transversely rugose, with indistinct rows of very narrow, long punctures. Beneath shining black, slightly bronzy on prosternum, which has the anterior margin arcuately emarginate, surface of abdomen marked with numerous oblong circles; tarsi and claws black; tarsal lamellæ yellow.

Length, 3.5 millimeters; width, 1.1.

One specimen from Mount Maquiling, Luzon (*Baker*).

Aphanisticus piceipennis sp. nov.

Elongate, somewhat depressed, uniformly piceous, with a bronzy reflection on head and prothorax, shining.

Head elongate, slightly wider posteriorly, much narrower than prothorax; front rather widely and deeply excavated between the eyes, the lateral sides of the excavation parallel; eyes with the inner side rather sharply margined as in *excavatus*, and placed at the extreme lateral part of the excavation; surface very finely granulate, moderately shining, with a few large, round punctures intermixed. Pronotum transverse, much wider than long; sides indistinctly crenulate, broadly, arcuately rounded to a little be-

hind the middle, then rather obliquely narrowed to posterior angles, which are obtuse; anterior margin broadly, arcuately emarginate; base bisinuate, with a rather abruptly rounded lobe at the middle; disk moderately convex, the convexity limited in front by a deep, transverse, angulate groove along the anterior margin, and behind by another, somewhat shallower groove along the posterior margin, limited on each side by a rather deep, broad depression; on each side an indistinct groove, perpendicular to the base; surface finely, densely granulate. Scutellum very small, triangular. Elytra a little wider than prothorax at base; humeral angles strongly angulate; sides slightly sinuate behind the humeri, strongly, obliquely narrowed from near the middle to the tips, which are separately rounded and very finely dentate; humeri not prominent, limited posteriorly by a depression along the lateral edge, causing the margin to become slightly flattened along the anterior third; suture slightly elevated near the apex; surface without costæ, very finely granulate, with indistinct rows of very narrow, elongate punctures and indistinctly rugose. Beneath black, shining; abdomen marked with numerous oblong circles over entire surface; anterior margin of prosternum broadly, arcuately emarginate; tarsi and claws black, tarsal lamellæ yellow.

Length, 2.9 millimeters; width, 1.

The type is from Mount Maquiling, Luzon (*Baker*); a paratype from Mount Banahao, Luzon (*Baker*). A specimen from Davao, Mindanao (*Baker*), is not quite typical of the species, the sides of the pronotum are more flattened and bronzy green, the transverse anterior groove on pronotum not quite as deep, and the disk with an obsolete transverse groove at the middle; otherwise it resembles the type and is best placed with this species for the present.

This species is closely allied to *A. bodongi* Kerrem., but from the description given for that species, the anterior margin of the prosternum is truncate, while in *piceipennis* it is broadly, arcuately emarginate. In *piceipennis* the elytra are not depressed along the suture and the measurements of this species are less than those given for *bodongi*.

Aphanisticus mindanaoensis sp. nov.

Oblong-ovate, rather convex, uniformly shining black, with a slight bronzy reflection on sides of pronotum.

Head very short, much narrower than prothorax; sides and front arcuately rounded, forming a half circle; front slightly,

broadly excavated between the eyes, these not sharply margined on the inner side nor placed forward on a projecting front; surface shining, very finely and densely granulate, with a few, large, round punctures intermixed. Pronotum transverse, much wider than long; sides rather broadly arcuate, widest at about the middle, then slightly, obliquely narrowed to posterior angles, which are obtuse; anterior margin broadly, arcuately emarginate, the anterior angles acute; base bisinuate, with a widely rounded median lobe in front of scutellum; disk rather evenly convex, sides slightly flattened, with a broad, rather deep depression near each of the posterior angles; surface finely, densely granulate, with a few large punctures intermixed. Scutellum very small, transversely triangular. Elytra about as wide as prothorax at base; humeral angles strongly angulate; sides slightly sinuate behind the humeri, strongly, obliquely narrowed from middle to the tips, which are separately rounded and finely dentate; humeri not prominent, just behind these a deep depression, causing the lateral margin to become slightly flattened along the anterior third; suture broadly elevated along posterior fourth; surface without costæ, finely, densely granulate and obsoletely rugose, with a few distinct punctures behind the scutellum. Beneath shining black, surface of abdomen marked with a few indistinct circles along the sides, becoming obsolete at the middle; anterior margin of prosternum broadly, arcuately emarginate; tarsi and claws black; tarsal lamellæ brownish.

Length, 3 millimeters; width, 1.25.

One specimen from Davao, Mindanao (*Baker*).

Aphanisticus foveicollis sp. nov.

Oblong-ovate, rather convex, dark bronzy, lateral margins of prothorax greenish bronze, shining.

Head very short, much narrower than prothorax; sides and front arcuately rounded, forming a half circle; front only slightly excavated between the eyes, the extreme front with a very small, abrupt, rather deep notch; eyes not sharply margined on the inner side nor placed forward on a projecting front as in *costipennis;* surface very finely, densely granulate, shining, with a few, large, round, indistinct punctures intermixed. Pronotum transverse, much wider than long; sides broadly, evenly arcuate, widest at middle; anterior margin broadly, arcuately emarginate, the angles rather acute; base bisinuate, with a widely rounded

median lobe in front of scutellum; disk rather suddenly convex, with the sides slightly flattened, the convexity with an indistinct groove posteriorly, and a broad, rather deep depression near each of the posterior angles; surface finely, densely granulate, with a few large punctures intermixed. Scutellum very small, transversely triangular. Elytra about as wide as prothorax at base; humeral angles strongly angulate; sides slightly sinuate behind the humeri, strongly, obliquely narrowed from near middle to the tips, which are separately rounded and finely dentate; humeri not prominent, just behind these a deep depression along the lateral edge, causing the margin to become slightly flattened along the anterior third; suture broadly elevated near apex; surface without costæ, finely, densely granulate and obsoletely rugose, with a few large punctures forming indistinct rows on the disk. Beneath shining black, surface of abdomen without distinct circular marks; anterior margin of prosternum broadly, arcuately emarginate; tarsi and claws black; tarsal lamellæ brownish.

Length, 2.75 millimeters; width, 1.25.

One specimen from Puerto Princesa, Palawan (*Baker*).

Aphanisticus unicolor sp. nov.

Elongate, rather convex, uniformly shining black.

Head very short, much narrower than prothorax; sides and front arcuately rounded, forming a half circle; front not distinctly excavated between the eyes, these not sharply margined on the inner side nor placed forward on a projecting front as in *costipennis;* surface very finely, densely granulate, with a few large, round, indistinct punctures intermixed. Pronotum transverse, much wider than long; sides broadly, evenly arcuate, widest at middle; anterior margin broadly, arcuately emarginate, the anterior angles acute; base bisinuate, with a large, rounded, median lobe in front of scutellum; disk moderately, evenly convex, with the sides slightly flattened; surface finely, densely granulate, with a few large punctures intermixed. Scutellum very small, triangular. Elytra a little wider than prothorax at base; humeral angles sharply angulate; sides strongly sinuate near middle, then obliquely narrowed to the tips, which are separately rounded and finely dentate; humeri not prominent, just behind these a deep depression, causing the lateral margin to become slightly flattened along the anterior third; suture broadly

elevated on the posterior fourth; surface without costæ, finely, densely granulate and obsoletely, transversely rugose, with indistinct rows of very narrow, long punctures. Beneath shining black; anterior margin of prosternum broadly, arcuately emarginate; surface of abdomen marked with numerous, rather distinct, oblong circles; tarsi and claws black; tarsal lamellæ yellow.

Length, 3 millimeters; width, 1.1.

Two specimens from Imugan, Nueva Vizcaya Province, Luzon (*Baker 8334, 8337*).

Aphanisticus trachyformis sp. nov.

Oblong-ovate, convex, uniformly bright bronzy black, shining.

Head very short, much narrower than prothorax; sides rather obliquely rounded; front slightly, broadly excavated between the eyes, these not sharply margined on the inner side nor placed forward on a projecting front; surface shining, very finely, densely granulate, with a few large round punctures intermixed. Pronotum transverse, much wider than long; sides broadly arcuate, widest behind middle, then more strongly narrowed anteriorly; anterior margin broadly, arcuately emarginate, the angles rather obtuse; base bisinuate, with a large, widely rounded, median lobe in front of scutellum; disk evenly convex, sides slightly flattened; surface finely, densely granulate, with a few large punctures intermixed, the punctuation becoming denser along the lateral margin. Scutellum very small, transversely triangular. Elytra about as wide as prothorax at base; humeral angles strongly angulate; sides slightly sinuate behind humeri, arcuately narrowed from the middle to the tips, which are separately, broadly rounded; humeri not prominent, just behind these a depression along the lateral edge, causing the lateral margin to become slightly flattened along the anterior third; suture elevated near apex; surface without costæ, very finely granulate and indistinctly rugose, with a few large punctures intermixed, becoming obsolete toward apex. Beneath shining black; abdomen marked with numerous slightly oblong circles over entire surface; anterior margin of prosternum slightly arcuate; tarsi and claws black; tarsal lamellæ brown.

Length, 3.25 millimeters; width, 1.5.

The type is from Tacloban, Leyte (*Baker 8335*). Another specimen from Dapitan, Mindanao (*Baker*), differs from the type in being darker, without the bronzy reflections.

Genus ENDELUS Deyrolle

Key to the species.[11]

1. Form robust; head much narrower than pronotum. E. violaceipennis sp. nov.
   Form elongate; head nearly as wide as pronotum ..... 2.
2. Pronotum broadly cordate ..... 3.
   Pronotum transverse, sides arcuately rounded 4
3. Black with violaceous reflections ..... E. palawanensis sp. nov.
   Uniformly bronzy ..... E. bakeri Kerrem.
4. Elytra bicolored ..... E. lunatus sp. nov.
   Elytra unicolored ..... 5.
5. Form elongate, agriliform; pronotum not twice as wide as long. E. agriliformis sp. nov.
   Form more robust; pronotum twice as wide as long. E. aeneipennis sp. nov.

Endelus violaceipennis sp. nov.

Broadly ovate, attenuate posteriorly, subconvex; head and pronotum bluish black, the latter with the anterior angles reddish, shining; elytra bright violaceous; beneath bronzy green.

Head elongate, slightly wider posteriorly, very much narrower than prothorax; front narrowly, abruptly, and deeply excavated between the eyes, lateral sides of excavation nearly parallel, median line distinctly marked from vertex to middle, becoming obsolete in front of epistoma; eyes prominent and strongly angulate, with the inner side strongly margined, placed at the extreme lateral part of the excavation; surface very finely granulate, with a few larger punctures intermixed and of a cupreous color on the anterior part, deeply impressed in front of epistoma, which is elevated, narrowly and deeply emarginate, and with the lateral parts extending along the inner side of the eyes; sides very much constricted below the antennæ, which are nearly contiguous. Pronotum transverse, about twice as wide as long, widest a little behind the middle, front distinctly narrower than base; sides rather strongly angulate at the posterior third, strongly rounded anteriorly, obliquely narrowed posteriorly to the hind angles, which are obtusely rounded; anterior margin with a large, widely rounded, median lobe, with the angles rather obtuse; base bisinuate, with a large median lobe, truncate in front of the scutellum; disk widely, transversely elevated anteriorly; sides broadly flattened, basal third with a widely rounded, transverse concavity; surface nearly smooth, with a few, indistinct, sparsely placed punctures. Scutellum

[11] *Endelus cornutus*, described by Kerremans from Luzon, has not been seen by me.

rather large, triangular, black, anterior margin truncate. Elytra a little wider than pronotum, humeral angles widely rounded; sides slightly sinuate and nearly parallel to just behind the middle, then abruptly, obliquely narrowed to the tips, which are conjointly, widely rounded and finely dentate; humeri prominent; surface nearly smooth, shining, with a few, sparsely placed, inconspicuous punctures, also with numerous, irregular elevations forming depressions as follows: A deep elongate depression at the base, another irregular one along the lateral margin reaching from the humeri to just behind the middle, causing the lateral margin to be distinctly flattened, an irregularly rounded depression on middle of disk, and a triangular one along suture near apex, which is broadly gibbous. Beneath with the sides of abdomen marked with irregular lines, becoming less distinct and crenulate on the median part; prosternum coarsely punctate; posterior coxæ with a distinct tooth at the middle of the posterior margin.

Length, 5.25 millimeters; width, 2.75.

One specimen from Davao, Mindanao (*Baker*).

This species is allied to *Endelus difformis* Deyr., but differs from that species in the coloration.

Endelus palawanensis sp. nov.

Elongate, attenuate posteriorly, subconvex, uniformly black, with a violaceous reflection, shining; beneath black.

Head large, distinctly wider anteriorly, slightly narrower than the prothorax, widely and deeply excavated between the eyes, a distinct median groove reaching from clypeal suture to occiput and dividing the head into two lobes; eyes prominent, strongly angulate, with the inner side slightly margined, and placed at the extreme lateral part of the projecting part; surface very finely granulate, with a few larger punctures intermixed; median line with a deep puncture at the middle and a similar one in front of epistoma, which is strongly elevated and narrowly constricted between the antennæ. Pronotum broadly cordate, twice as wide as long, widest at anterior fourth; sides finely crenulate, arcuately rounded anteriorly to near the middle, then strongly, obliquely narrowed to the posterior angles, which are obtuse; anterior margin slightly lobed at middle, the angles rather acute and protruding; base bisinuate, with a large median lobe truncate in front of scutellum; disk rather convex, with the sides somewhat flattened, the convexity formed by a transverse elevation joined on the median line to a common anterior eleva-

tion along the frontal margin; surface nearly smooth, with a few, indistinct, round, shallow punctures. Scutellum rather large, triangular, truncate in front. Elytra distinctly wider than pronotum at base; humeral angles obtusely rounded; sides nearly parallel to the posterior third, then obliquely narrowing to the tips, which are widely and separately rounded and rather strongly dentate; humeri rather prominent; surface slightly rugose, with a few, rather large, inconspicuous punctures; each elytron with numerous irregular elevations, forming shallow depressions as follows: Three irregular-shaped ones along the lateral margin, a deeper transverse one along base, and three irregular round ones along the suture, the one near the tip being more elongate. Beneath marked with a network of indistinct crenulate lines.

Length, 3.75 millimeters; width, 1.5.

One specimen from Puerto Princesa, Palawan (*Baker 8336*).

This species is allied to *Endelus bakeri* Kerrem., but differs from it in coloration and in having the elytra not so distinctly punctured.

Endelus bakeri Kerremans.

Two specimens which I take to be this species are from Los Baños, Luzon (*Baker 8322*).

Endelus lunatus sp. nov.

Elongate, attenuate posteriorly, rather convex; head and pronotum bright greenish bronze; elytra violaceous with green spots; beneath black with a bronzy reflection.

Head short, slightly narrower than prothorax, widely concave between the eyes; median line not distinctly impressed, except at the middle; eyes prominent, strongly angulated, inner margin slightly margined, placed at the anterior lateral part, which is scarcely projecting; surface smooth, shining, with rather large circular marks becoming more numerous on the vertex, two deep, semicircular depressions in front of epistoma, which is elevated and strongly narrowed between antennæ. Pronotum transverse, two and one-half times as wide as long, widest at middle; sides feebly crenulate, evenly, arcuately rounded; anterior margin slightly lobed at middle, the angles acute and protruding; base bisinuate, with a large median lobe truncate in front of scutellum; disk broadly, transversely elevated anteriorly, the sides flattened, with a wide transverse concavity along the posterior margin; surface nearly smooth, indistinctly marked with circles, becoming crenulate on the anterior part. Scutellum green,

rather large, triangular, truncate in front. Elytra about as wide as pronotum; humeral angles rather obtusely angulate; sides slightly sinuate near hind femora, slightly narrowed from base to posterior third, then more abruptly narrowed to tips, which are conjointly, widely rounded and finely dentate; humeri rather prominent; surface with a rather deep transverse depression along base and another elongate one along lateral margin behind humeri, also with rather large, sparsely placed punctures, except on the green spots, where the surface becomes very finely granulate, with a few larger punctures intermixed; the arrangement of the green spots is as follows: Each elytron with a round spot on the humerus, a smaller one along the side of scutellum, a transverse crescent-shaped spot just behind the middle, with the tips pointing forward, but not reaching suture nor lateral margin, a large round spot at the posterior fourth, and a less distinct one at the apex. Beneath very finely granulate and marked with a network of crenulate lines.

Length, 3.25 millimeters; width, 1.4.

One specimen from Cuernos Mountains, Negros (*Baker*).

This species is allied to *Endelus scintillans* Deyr., but differs from that species in the arrangement of the spots on the elytra.

Endelus agriliformis sp. nov.

Elongate, very slender, agriliform, attenuate posteriorly, head and pronotum coppery bronze; elytra dark reddish bronze with a slight violaceous reflection; beneath bronzy.

Head short, nearly as wide as the prothorax, widely concave between the eyes; median line slightly impressed from vertex to middle and ending abruptly in a small deep pit; eyes prominent, slightly angulate but not distinctly margined on the inner side, placed at the anterior lateral part, which is not projecting; surface finely, densely granulate, with a few large punctures intermixed, two deep oblong depressions below the antennal cavities; front strongly constricted between the antennæ, which are nearly contiguous; epistoma triangular, anterior margin slightly arcuate. Pronotum transverse, one and two-thirds times as wide as long, sides arcuate, a little wider in front than behind, widest at about the basal third; anterior margin nearly straight, the angles obtuse; base bisinuate, with a large median lobe, truncate in front of scutellum; disk moderately convex, with a wide transverse concavity along the posterior margin, becoming more deeply impressed near the lateral angles, and a similar transverse depression at the middle; surface finely

granulate and reticulate. Scutellum rather large, triangular. Elytra about as wide as the pronotum; humeral angles obtusely rounded; sides strongly sinuate at the posterior coxæ, then rather strongly expanded and gradually attenuate to the tips, which are separately rounded and finely serrate; humeri rather prominent; surface with a broad deep depression at base, strongly, transversely rugose and sparsely punctate. Beneath very finely reticulate and distinctly crenulate.

Length, 4.75 millimeters; width, 1.25.

One specimen from Davao, Mindanao (*Baker*).

This species resembles a very slender *Agrilus*.

Endelus aeneipennis sp. nov.

Elongate, moderately robust, slightly attenuate posteriorly, rather convex; head and pronotum bright greenish bronze; elytra aëneous; beneath bronzy.

Head short, slightly narrower than prothorax, widely concave between the eyes; median line not distinctly impressed, except for a shallow pit at middle; eyes prominent, not strongly angulate, inner side slightly margined, placed at the anterior lateral part, which is not projecting; surface distinctly, densely granulate and indistinctly marked with fine crenulate lines, with two deep depressions behind the antennal cavities; front strongly narrowed between the antennæ; epistoma triangular, anterior margin slightly arcuate. Pronotum transverse, twice as wide as long, widest at about the middle; sides evenly, arcuately rounded; anterior margin broadly lobed at middle, the angles rather obtuse; base bisinuate, with a large, abruptly rounded, median lobe in front of scutellum; disk moderately convex, with a wide, transverse concavity along the posterior margin and a median transverse depression, widely interrupted at middle; surface finely, densely reticulate, with numerous distinct crenulate lines. Scutellum rather large, triangular. Elytra about as wide as pronotum; humeral angles obtusely angulate; sides nearly parallel to apical third, then slightly attenuate to the tips, which are separately, broadly rounded and finely serrate; humeri not prominent; surface with a shallow basal depression and a similar depression along the lateral margin behind the humeri, strongly rugose and rather densely punctate. Beneath marked with a network of indistinct crenulate lines.

Length, 4.5 millimeters; width, 1.5.

One specimen from Malinao, Tayabas Province, Luzon (*Baker*).

A CASE OF HUMAN COCCIDIOSIS DETECTED IN THE PHILIPPINE ISLANDS, WITH REMARKS ON THE DEVELOPMENT AND VITALITY OF THE CYSTS OF ISOSPORA HOMINIS (RIVOLTA)

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FOUR PLATES AND ONE TEXT FIGURE

When Woodcock, in an appendix to a paper by Ledingham and Penfold, published in 1915(18) announced the discovery of sporozoan cysts in the stools of soldiers invalided home from Gallipoli, he reopened the entire subject of coccidiosis in man. Knowledge bearing on this subject was, at that time, on a very uncertain basis, and the general belief was that the coccidia of man were identical with those found in the rabbit and in the cat. Woodcock was not successful in his attempt to obtain development of the cysts and, therefore, could give only a very incomplete account of what he had found.

However, confirmation came very quickly from Low and from Wenyon(17) and within a year or two a number of cases of infections with *Eimeria* and *Isospora* were detected by workers in the war zones. Published figures of the cysts made it quite apparent that the species concerned were not the familiar parasites of the rabbit and the cat. Circumstances connected with these findings indicated that the focus of infection lay in the eastern Mediterranean area, and subsequent observations have, in a large measure, confirmed this. On the basis of these reports I published a short paper in 1918(9) calling attention to the problem that seemed to be arising. At that time I raised a question as to the specificity of the parasites found in man, and also ventured the prediction that under war conditions, coccidial infections in man were likely to crop up at any time or place.

Since the publication of that paper Dobell, in his admirable monograph on the coccidia of man,(3) has stabilized the situation as regards the identity of the organisms involved and has completely analyzed the literature. Moreover, later reports have shown that *Isospora hominis* (Rivolta, 1878) emend. Dobell,

1919, has nearly circumnavigated the earth, proceeding east and west from the eastern Mediterranean area and arriving at Bombay and possibly Saigon in an easterly journey from the region of Gallipoli and, in a westerly direction at Manila, probably by way of France and the United States. It is this last case that will be reported in this paper.

This case was presented by an American, a chemist by profession, 32 years old and a resident of Georgetown, Illinois. He spent the years 1915–1916 as a member of the technical staff of the Bureau of Science, Manila, and then returned to the United States, almost immediately proceeding to Trenton, Ontario. He lived there for about a year, and, so far as he had knowledge, was not in contact with any person who had returned from the war zones, or who had ever been in the eastern Mediterranean region or in Egypt. At Trenton, his meals were prepared by a Chinese cook.

During the years 1918 to 1920, he occupied a position at the Government smokeless-powder plant at Nitro, West Virginia, a war settlement situated about 24 kilometers from Charleston. During that time he made one or two short trips to New York. The sanitary conditions at the powder plant he describes as excellent. He bought food supplies from the Government stores. He purchased green vegetables from local produce dealers, but knew nothing of the sanitary conditions at the farms or the antecedents of the farm hands. He employed no servants and all the meals were cooked by members of the family.

The personnel of the powder plant included laborers from many parts of Europe, and, he thinks, men from the eastern Mediterranean area. He also came in contact with men returned from the war zones in France, but never messed with them.

The patient sailed from San Francisco for the Philippines on November 19, 1920. He went ashore in Japan, but ate only one meal ashore. This was a dinner at a tea house in Kobe. None of the others who were at this meal were in Manila at the time the case came to my attention, so their stools could not be studied. He arrived in Manila on December 19.

Inquiry into the previous medical history of the patient failed to reveal anything of note except an attack of typhoid fever in 1910. This was the only intestinal trouble from which he ever had suffered. His bowels always had been regular, and he had suffered neither from constipation nor from diarrhœa. His wife

had an attack of dysentery in Manila in 1916 and has experienced some bowel trouble since her return to the United States. I was led to believe that her dysentery was of the amœbic type.

Late in January of this year, the patient went to Mindanao, and into the Cotabato country. He went on a hard field trip about February 5, 1921, for which he was not physically prepared. He had three days of hard marching in the hot sun and, as a result, returned to headquarters completely exhausted. He did not take proper care of himself and sustained a chill. A period of constipation set in, and he sought relief with compound cathartic pills. These acted promptly, and he began to pass frequent watery stools which, however, were not accompanied by tenesmus. He saw neither blood, pus, nor mucus in the stools. This diarrhœa continued intermittently for several days.

Feeling rather sick, the patient returned to Manila. The trip consumed eleven days on the boat, during which time he had little if any appetite and ate very lightly. He had, however, accumulated something of an appetite on his arrival in Manila on February 26, and that night he visited a restaurant and ate a heavy meal consisting of beefsteak, potatoes, celery, and a variety of other things. He repeated this the following night.

The diarrhœa recurred on the morning of February 28, and continued all the following day. The movements were very frequent and watery in character. On the afternoon of March 1, he came to the Bureau of Science where his stool was examined by a member of the staff. The microscopist subsequently stated to me that the stool contained numerous small amœbæ, but no blood. These amœbæ were not identified. The patient then began to treat himself with Alcresta ipecac tablets.

On March 3 I returned from an out-of-town trip and the case was referred to me. I saw the patient the following day, at which time he informed me that the watery movements had increased in number and were inconveniently frequent. He said that he had suffered no real abdominal pain or tenesmus, but that there was considerable abdominal discomfort of a rather vague character due, he thought, to gas. His abdomen was not tender to palpation. His stool was dark in color and diarrhœal in character, but bore absolutely no evidence of dysentery. No amœbæ were found at this or any subsequent examination, and there was no evidence of blood or tissue elements of any kind. One undeveloped oöcyst of *Isospora hominis* was

discovered in the first preparation, but no other animal parasites were ever found. He had a light Blastocystis infection.

I questioned the patient and learned that he was taking the equivalent of 90 grains of ipecac daily. This led me to suspect that much of his trouble was due to the ipecac. I therefore told him to discontinue taking the drug, for I saw no indication for continuing it, and within twenty-four hours his fæces had become formed.

The patient did not report to me again until March 12, at which time he passed a hard, formed, rather dry stool. Microscopically, the stool contained rather numerous cysts of *Isospora,* Blastocystis, and a few Charcot-Leyden crystals of the short form. Parenthetically it might be mentioned that Noc,(12) who has recently reported a case of infection with this parasite, which I shall discuss later, found in the stools of his patient some crystals in the form of elongated lozenges (*losange allonge*) which he believes were fatty-acid crystals. These, I am inclined to believe, may have been Charcot-Leyden crystals. As a check, one of the cysts was measured and was found to be 26.6 μ in length by 14.9 μ in breadth.

On March 15 the patient came to me again and passed a light, yellowish brown, soft-formed stool at the laboratory. The cysts were much more numerous than before. The following day the patient passed another stool at the laboratory. This consisted of two distinct portions—an apparently normal, formed, brown mass and a greenish brown, bile-stained and very soft portion passed after it. Cysts were very numerous.

On this day (March 16) the patient looked ill and anxious. On my instruction he had been eating carefully and avoiding all food that would have a tendency to lay stress on his intestinal tract. He seemed to suffer no actual pain, but he complained of a dull, dragging sensation in the abdomen and slight nausea at times.

He was no better when he next visited the laboratory on March 21. The stool passed that morning was light yellow and again consisted of two portions—a solid portion and one, passed after it, that was very soft to watery, verging on diarrhœa. It, also, contained numerous oöcysts of *Isospora.* Microscopically, I found numerous strands of mucus containing epithelial cell débris, but no blood nor pus. The stool certainly was not dysenteric in character, but it showed unmistakable evidence of a morbid process somewhere in the intestinal tract. I carefully

studied the epithelial cells in the hope of finding intracellular stages of the coccidium, but without success. Several slides were fixed and stained, but later examination of these was likewise barren of results.

The patient complained greatly of fatigue and lassitude. He reported that he was particularly uncomfortable at night and that he obtained relief by pressing the pillow against his abdomen. He was very restless at night and dreamed a great deal. On arising in the morning he felt completely worn out. On this particular morning he had felt somewhat better and had read the newspaper comfortably before going down to breakfast. At the table, however, he lost his appetite and ate only some papaya, prunes, and shredded wheat biscuit—not much of any of them. He said that he experienced something approaching an appetite for about one out of every three meals. This condition continued until I lost sight of the case, although the patient showed improvement in other ways. He had, in the meantime, lost 15 pounds in weight since the onset of the trouble. His temperature showed no tendency to rise except about half a degree Fahrenheit for a day or two following his return to Manila. The flatulence which troubled him before had disappeared to a large extent, but he still suffered from the dull sensation of uneasiness and discomfort in the abdomen, although there was no actual pain. The nausea had disappeared, but his appetite had not returned. Normally, he stated, he was "an enthusiastic eater." At times his tongue was coated, and he was much annoyed at night by a bad taste in his mouth which made it necessary for him to arise, brush his teeth, and gargle with antiseptic solution.

The next examination of the patient's stool was made on March 30. On that day his stool presented the same general characters as the two preceding specimens. The first portion was dark yellow in color and fully formed; the second was lighter yellow and very soft. No cysts were discovered in the careful examination of ten fresh preparations selected from both portions of the stool. Concentration by the method of Cropper and Row of about 2 grams of the stool, made up of samples selected at random from both portions of the specimen, likewise failed to disclose any cysts.

The patient still complained of a slight degree of abdominal discomfort and of anorexia. On the whole, however, he seemed

to feel better, and his color and general appearance showed improvement. He had gained no weight.

I saw the patient for the last time on the night of April 10, at which time he furnished me another stool specimen. This was a seemingly normal, formed stool, light yellow in color. Examination of it on the following morning showed that he still retained his infection, for a few cysts in the sporoblast stage were found on examination of the first preparation.

The following day the patient sailed for the United States. His condition had improved, and he stated that he felt much better. I referred him to Prof. Charles A. Kofoid, of the University of California, in order that the state of his infection might be determined on his arrival in California.

To summarize the clinical side of the case:

It seems likely that the patient contracted his infection in the United States. The population of the camp at Nitro was such that it is not improbable that it may have numbered infected persons hailing either from the eastern Mediterranean zone or from the trenches in France. That is to say, the patient's contacts in other places were much more unlikely to have been infected with *Isospora*. Moreover, during a residence of seven years in the Philippine Islands, I have studied thousands of stools of healthy persons and of persons suffering from intestinal disorders, who have hailed from nearly all portions of the Islands; and, until I ran across this case, I never encountered a case of human coccidiosis, notwithstanding I have had the possibility in mind ever since the first cases were reported abroad in 1915 and 1916.

Apparently the onset of the trouble came about February 9. This would not necessarily mean that the patient must have contracted his infection only a short time previously. It is not improbable that some digestive disturbance may have occurred at this time, that was quite separate from the coccidial infection. With a light initial infection it is conceivable that a fairly long period might elapse before involvement of the intestinal mucosa became extensive. It is to be doubted if every merozoite discharged at schizogony finds its host cell. On the contrary, a large proportion of them, particularly those formed in cells which do not lie deep in the crypts, must be caught in the flow of the intestinal contents and swept on to perish for lack of suitable food. This is probably just what happens in the early stages of the infection, and it is only later that the organisms work up into the crypts where they are more or less secure.

That the patient had an infection with some species of amœba would appear evident from the findings in the Bureau of Science; but the species was not determined, and they never reappeared in the stool after the day they were discovered. The patient, it is true, had taken heavy doses of ipecac; but his stool, at no time while he was under my observation, showed any of the elements characteristic of dysentery of any type.

The clinical symptoms seemed to be fairly constant, and they abated with the subsidence of the infection. The stools at times were watery, but always feculent and contained no pathologic elements aside from shed epithelial cells occurring in groups of five or even more cells, which despite their surroundings looked remarkably healthy—more as if they had been mechanically detached from their bases than as if they had been subjected to an inflammatory process. There was neither pain, griping, nor tenesmus, though, of course, there is no reason why the patient should experience tenesmus when one reflects on the anatomical site of the lesion. There was, however, a constant, dull feeling of discomfort in the abdomen, sometimes accompanied by flatulence, that the patient found very hard to define, but which, nevertheless, was perfectly real. The patient also suffered from fatigue and lassitude, restlessness at night, and occasional nausea. At times, particularly at night, he had a bad taste in the mouth and his tongue usually was foul, notwithstanding his bowels moved every day. Anorexia was a prominent and persistent symptom. The patient, like Noc's recently reported case,(12) also lost weight.

The general impression seems to be that these infections are extremely transitory, and at least one writer has placed three weeks as about the limit of their duration. I think there is no doubt that there are at least exceptions to that rule, if it is a rule. The infection persists long enough for the patient to journey from Mesopotamia to Bombay or from Germany to Senegal, or from France to America and lastly from the eastern United States to Manila, a journey of five weeks. This, added to the time the last-named patient was under observation, comprehends a period of more than four months, *and he was still infected when he parted from me,* which rather effectually disposes of the theory that these infections are "purely transitory." During that time the patient's stool yielded but one negative examination, and I have little doubt that, if I had spent more time on it, I should have found some cysts.

DETECTION OF ISOSPORA INFECTIONS

Having had the opportunity to study the cysts of *Isospora hominis* it is hard for me to escape the conclusion that many infections with this organism have been overlooked and that the infection is probably more common than present reports would indicate. It is also a fact, to which some significance may be attached, that the present geographical distribution of *I. hominis* corresponds rather closely to the geographical distribution of protozoölogists experienced in coprology. That point, however, will be discussed later.

The difficulties in diagnosis are several. The oöcysts are exceedingly transparent and the protoplasm is often so widely separated from their inner aspects that the cysts are practically invisible under the powers ordinarily employed by experienced microscopists in searching preparations of fæces. Then, the oval to rounded contour of the zygotes and sporoblasts and their greenish coloration render it extremely difficult to avoid mistaking them for some of the small plant forms so common in fæces. After one has studied these cysts for a while, under high as well as low powers, it becomes somewhat easier to pick them up under the low dry objective; but one has to have the experience first. However, the recognition of these cysts in any stage of development affords no real difficulty to any person who has had previous experience with the coccidia. It is the tyro, who has not studied the coccidia, who is likely to miss the cases.

Two points should be carried in mind by those searching for these cysts. Preparations should be exceedingly thin and well diluted with water—even thinner than the preparations usually made for the detection of intestinal protozoa and the ova of parasitic worms. The light should be well regulated—that is to say, carefully cut down, but not too much. Under these conditions the outline of the oöcyst may be visible even at the lowest magnifications ordinarily employed in work with fæces; that is, 100 diameters. India ink, diluted about one-half with water, and Donaldson's iodine-eosin mixture I have found useful in picking up cysts, for their clear, oval shape in these fluids sharply differentiates them from other objects in the preparation. The ink and the iodine-eosin mixtures should not be used when it is desired to make camera lucida drawings or measurements of the cysts, for I find the fluid flows over the rounded ends of the cysts and obscures their outlines. The cysts come down nicely on concentration by the method of Cropper and

Row and are much easier to pick up than in the usual slide emulsion.

So far as I can learn from this case, there are no criteria other than the finding of the cysts that will enable a sure microscopical diagnosis of intestinal coccidiosis. The stool affords no constant characters other than the cysts, so far as I have seen, that will render it possible to make a presumptive or tentative diagnosis, as is possible in the case of the dysenteries. If active symptoms should appear before cyst formation begins, there would appear to be nothing to do except to wait until the cysts begin to appear in the fæces, as they will in due time. Porter(13) in writing on this subject says, however, "The infective oöcysts and sometimes epithelial cells containing trophozoites or schizonts are found in fæces and serve for diagnosis." I cannot agree that the finding of infected cells in the fæces is sufficiently constant to be of much aid in microscopic diagnosis. At least that was not my experience with this case.

In these infections the destruction of tissue by the parasite is limited to the epithelial cells of the intestine and it is not a necrotic process. It is conceivable that in extensive infections secondary bacterial invasion might occur and its products make their appearance in the stools, but such stools could scarcely be expected to be in any way characteristic of coccidiosis. It seems to me safe to say that in the general run of cases, pus and blood will not appear in stools. This, notwithstanding Noc has reported finding blood in the stool of his Dakur case. Mucus may be present and Noc, and Porter, as well as I have seen desquamated epithelial cells. Noc was fortunate enough to find one containing what would appear to have been a trophozoite of *Isospora*. I saw these epithelial cells on one occasion only; but, although I searched carefully, I found no intracellular parasites.

Some day, some one may succeed in making recognizable stained preparations of coccidial cysts, but for the present I should advise the amateur not to waste his time trying to stain them, for he will not succeed by the usual methods. Indeed he may even have trouble in fixing them. Such observations as have been made on the cysts of the coccidia have been made on fresh material, and we have no real knowledge of the cytology of the organisms in this stage of their life cycle.

Another thing that will trouble the inexperienced is the rather large number of unfertilized and otherwise abnormal cysts that will be found on study of a case. For this reason I have thought

it desirable to figure a number of these cysts (Plate 3, figs. 1 to 12). The oöcysts also show considerable variation in outline, from those that are virtually oval to those that resemble a bottle or elongated flask—a shape that is more or less characteristic of the species. This variation is shown in the plates that accompany this article.

The oöcyst, itself, is a delicate, transparent, double-contoured affair with a perfectly smooth surface. Some writers have described a delicate membrane lying within the cysts and a structure at the constricted end that has been interpreted as the micropyle. I have not been able to convince myself of the presence of either of these in the cysts I have studied; but I have been compelled to make my studies at this time with achromatic objectives, and it may be that my failure to demonstrate them has been due to lack of proper optical equipment. Noc(12) suggests that the bottle-neck appearance of the cysts may be due to the pressure of the elongated sporocysts as they rotate within the oöcyst. I think this interpretation is incorrect, for one frequently finds undeveloped cysts which show the constriction at one end (vide the plate accompanying Dobell's article).(3)

I regret I cannot give adequate treatment of the dimensions of these cysts at the present time. Recently, the cross hair on my filar micrometer became broken, and such measurements as I have made have been made with an ordinary ocular micrometer and a stage micrometer in whose accuracy I have not great confidence. I am giving measurements of nine oöcysts selected at random, and they are shown in Table 1.

TABLE 1.—*Measurements of nine oöcysts of Isospora hominis.*

Length.	Breadth.
μ	μ
33.2	13.6
36.4	13.6
39.0	14.5
35.8	15.8
39.1	12.7
37.3	18.2
38.2	19.1
39.1	19.4
40.0	17.6

These measurements were made with a Ramsden micrometer ocular at a magnification of about 715 diameters.

Nearly all of the measurements shown in Table 1 will be seen to exceed the dimensions reported by other workers. Dobell(3)

says the cysts measure from 25 μ to 33 μ in length and that they have a breadth at the widest part of ca. 12.5 μ to 16 μ. That is to say, the width of the cysts is approximately half their length. However, as he has pointed out and as my illustrations show, the relative dimensions are not constant, although the long and slender forms predominate over those that are short and plump.

In freshly passed stools the zygotes are practically undeveloped, and may show very little shrinkage away from the walls of the oöcyst. However, one not infrequently picks up cysts that have undergone sporoblast formation, but that is the limit of development in the freshly passed stool. The cell body is coarsely granular, has a distinct greenish tint and, under suitable illumination, the mass shines like a gem. The resemblance to certain plant forms found in the fæces is rather striking at first, but one soon becomes able to pick them out from the general collection of plant and animal forms.

SPOROBLAST FORMATION

The preliminary stages of spore formation appear to take place rather early, and may be seen in some cysts within two hours after the stool is passed. Meanwhile the protoplasmic mass changes considerably in shape and shrinks away from the cyst wall rather rapidly, finally forming a practically spherical mass in the center of the cyst. A clear area often appears in this mass, toward the center, as if the granular inclusions had been forced away from the center (Plate 1, fig. 1). This may or may not mark the site of the nucleus. Frequently, however, two or more of these clear areas form in the cell (Plate 1, figs. 2 and 3), and I am inclined to suspect that the appearance may be connected with cylosis, which becomes fairly active in the cell at this stage of development. The spherical form assumed, the cell appears to lose much of its passive nature. It undergoes almost constant change of form. These changes are slow, very much in the nature of the movements of leucocytes, or some of the very sluggish amœbæ, but they can be followed, nevertheless. The protoplasm is in a condition of constant though slow cyclosis in which the granules are circulated round about through the cell. On the outer aspect, from time to time, appear clear, hyaline processes, devoid of inclusions, that superficially resemble pseudopodia (Plate 1, fig. 4). These may also appear in the early sporoblast stages as is suggested by Wenyon's figure (fig. 2, p. 625).(16) These form slowly and appear to develop more by the retraction of the endoplasmic granules from

the periphery and a metabolic change of form, than by the actual extrusion of the protoplasmic mass, as is the case in pseudopodia formation.

I was able to follow the process of sporoblast formation in one cyst (Plate 1, figs. 5 to 10; Plate 2, fig. 1). The process of plastogamy, from the time of the appearance of the first signs of cleavage of the zygote, was forty minutes. Of course, there is no way of estimating the time of the entire process, for it is impossible to tell whether division of the nucleus occurs soon after zygosis or is deferred until just before division of the cell body occurs.

The cyst in question was first seen by me at 10.40 a. m. The temperature of the laboratory at that time was 28° C., and it did not appreciably vary from that during the process. The material was mounted in physiological salt solution and sealed with vaseline. The zygote, at that time, showed a distinct equatorial constriction (Plate 1, fig. 5). The cyst was sketched rapidly under the camera lucida. At 10.55 the cleft had become quite sharp (Plate 1, fig. 6). At this time the cell showed great protoplasmic activity. The outline of the cell was constantly changing and cyclosis was very marked.

At 11.03 the outline of the dividing cell had lost its irregularity and was becoming rounded (Plate 1, fig. 7). The cleft had distinctly deepened. The outer aspect of the cell was still more sharply defined and the cleft much deeper at 11.08 (Plate 1, fig. 8), and at 11.17 the daughter cells were connected by a very slender strand only (Plate 1, fig. 9). At this stage, the posterior cell (lowermost in the figure) showed a slight transverse elongation, and at the same time a distinct movement of the two cells was observed. This was a slight to-and-fro rotation, as if the two cells were geared (text fig. 1); and when separation had become complete, at 11.19, at which time the cells moved apart, this movement became more pronounced, and it continued until after 4 o'clock in the afternoon.

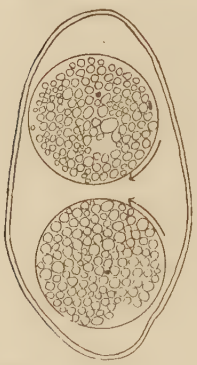

FIG. 1. Oscillation of sporoblasts following cell division in *Isospora hominis* (Rivolta).

At 11.30 o'clock, eleven minutes after separation of the cells had taken place, the cells were widely separated (Plate 1, fig. 10). The ectoplasmic layer began to show a tendency to stiffen, although it was still sufficiently plastic to allow for slight changes of external form. The general spherical shape was main-

tained until 12.40 o'clock, when the sporoblasts were seen to have elongated (Plate 2, fig. 1) and there was a distinct separation of the protoplasm from the membranous capsule that had formed externally, while the granular cell contents showed a tendency to clump toward the center of the cells. Beyond changes in the positions of the sporoblasts, nothing further was observed during the day; a defect in the mounting resulted in the loss of the cyst during the night.

This clumping of the granules and differentiation of the protoplasm observed in this particular cyst is not the invariable appearance. More frequently, it would seem, sporoblasts retain their spherical form for a while in the sporocyst state, and the distribution of granules through the cells remains fairly uniform, as is seen in Plate 2, fig. 2, which was drawn from another specimen. Moreover, development of the sporocysts is not necessarily synchronous, as will be seen by another cyst (Plate 2, fig. 3).

The next steps in sporozoite formation would seem to consist in the elongation of the sporocysts which often, although not invariably, become titled at an angle to the long axis of the oöcyst (Plate 2, fig. 11); the gradual condensation of the protoplasm into a more-compact mass; and the concentration of the so-called sporocystic residuum toward the center of the sporocysts.

Unfortunately, I have been unable to find material that will yield information as to the further steps in sporozoite formation. Indeed, the process of sporogony could scarcely be worked out completely in the study of material obtained from a limited number of stool examinations. The only cyst I found that seemed to show a definite step (Plate 2, fig. 4) had been in the ice box at 10° C. for forty-eight hours. It was rather difficult to focus down through the mass of granules and distinguish the details at the lower focal levels; but the protoplasm had apparently expelled the nutritional granules, undergone concentration, and assumed a crescentic form preparatory to the first sporozoite division. That was the only cyst I have so far encountered that showed definite evidence of any stage between the sporocyst and the completely developed tetrazoic spores (Plate 2, figs. 5 to 12; Plate 3, fig. 10).

The cyst shown in Plate 3, fig. 6, is in all probability a cyst that had undergone partial sporozoite development through the first sporozoite division in one sporocyst, but had failed of further development through some untoward external condition,

or possibly because of insufficient store of food supply. It was taken from the stool passed on March 16, that had been in the ice box at 10° C. for forty-eight hours and had then been sealed on a slide in physiological salt solution. Another cyst (Plate 3, fig. 8), also abnormal, was found in the same preparation.

As I have said, most of the cysts found in freshly passed fæces are in early zygote stages, but sporoblast stages are not infrequently found. However, I have seen no later stages in the fresh material. In his monograph, Dobell(3) says: "Development of the spores takes place outside the host and requires several days for its completion." This is more or less in harmony with the behavior of cysts of other species of *Isospora,* and probably is the general rule with this species; but it is not by any means invariable, as I have found on studying this case. Certain factors may intervene to yield cysts in the infective stage at a much earlier period. The bacteriological and general chemical and physical conditions, as oxygen supply, in the fæcal mass probably play an important part, as may also a state of constipation which delays the passage of the cysts. For instance: The stool passed at 8.45 a. m., on March 16, consisted of two distinct portions—a normal, formed, brown mass and another portion, passed after it, that was greenish brown and soft in consistence. It was immediately examined, and both portions were found to contain oöcysts in an early stage of development.

The stool was examined again the following day at 4.30 p. m., approximately thirty-two hours after its passage. The temperature during this time had varied between 28° C. and 30° C. The formed portion of the stool contained undeveloped zygotes, sporoblasts, sporocysts, and a number of fully developed cysts and some that were degenerated (Plate 2, fig. 7). The softer portion of the stool yielded no fully developed cysts. A few cysts were seen that had gone as far as sporoblast development, but there were many cysts that clearly were undergoing degenerative changes.

Of course, this is only an isolated case, but it does show that under certain conditions the cysts may become infective in considerably under two days, a fact that must be taken into consideration in the epidemiology of the disease. The preservation of the cysts in the formed portion of the stool was excellent. A specimen of the material was examined on April 2, after it had rested in a bottle on the laboratory shelf since it was passed, and was found to contain numerous, fully developed and healthy-looking cysts.

The stool passed on March 15, which was light yellowish brown and soft-formed—much softer than the other—was examined on April 1, after it had rested under similar conditions. It contained a number of healthy-appearing cysts in full development, but with shrunken oöcysts, and also large numbers of cysts in various stages of development up to full development, which had undergone marked degeneration in addition to the wrinkling of the oöcyst. Contraction or wrinkling of the oöcyst does not, however, necessarily mean that the cyst is not infective, as I shall try to show later. Death of the protoplasm is probably quickly followed by its disintegration, even under the double protection afforded by the oöcyst and the sporocyst.

The proportion of cysts discharged from the intestinal mucosa that fail to develop for one reason or another, is probably rather large, and I am at present trying to determine that approximately, but it will take the consideration of many cases to give any definite idea. It would seem to me to be a much larger proportion than is the case with the cysts of *Entamœba histolytica*. From time to time, one encounters cases of infection with the latter organism in which the greater number of the cysts examined are in the mono- or binucleate stage. As Dobell(4) has pointed out (p. 48), and as my own experience corroborates, these cysts undergo no further development after they have left the intestine. I am inclined to believe that they hail from nests of amœbæ located in the tissues lying rather low down in the intestine, whence the journey to the outer world is too short to give them time for full development. These cases are relatively uncommon, and it is likely that such cysts are incapable of infecting a new host.

So far as my observations have led me, I am inclined to believe that there are three general causes underlying the failure of these cysts of *Isospora* to develop: (1) failure of the macrogamete to be fertilized by a microgamete, (2) failure of the macrogamete to store sufficient energy in the form of food reserve to carry it through the rather dynamic processes of division and differentiation which, from the behavior of the zygote during the earlier stages of sporogony, would seem to call for the expenditure of not a little energy, and (3) a variety of untoward environmental conditions.

Four undeveloped and more or less degenerate cysts are shown (Plate 3, figs. 1, 3, 4, and 11). Fig. 1 shows a cyst, the protoplasm of which, it is true, is somewhat vacuolated, but perhaps not unduly so, although I have not sufficient knowledge of the

normal protoplasmic appearance of these cysts to judge well. This cyst would appear to have failed of fertilization, for it was three days old when examined. What has happened to two of the other cysts (Plate 3, figs. 3 and 4) is a little hard to say, for they are badly degenerated. The cyst shown in fig. 3 has apparently suffered from osmotic changes, and the protoplasm presents a picture frequently seen in dying protozoa. The cyst shown in fig. 11 probably failed of fertilization. Its appearance recalled, somewhat, the appearance of the contents of an unfertilized *Ascaris* ovum. Five of the other cysts (Plate 3, figs. 5 to 9) clearly owed their destruction to causes other than failure to secure fertilization, for they had progressed considerably toward complete development. Indeed, it is not unlikely that the cyst shown in fig. 7 actually attained full development and went to pieces later. The cyst shown in fig. 5 had been in the ice box for forty-eight hours and had then been sealed in 10 per cent potassium bichromate solution for twenty-four hours. The cyst in fig. 6 had received similar treatment, except that it had been sealed in physiological salt solution. The cyst in fig. 7 had been in the ice box for one week and had then been allowed to develop overnight in the laboratory. The preparation in which it was found contained numerous fully developed and perfectly healthy cysts as well as a few others that had degenerated. Figs. 8 and 9 were also ice-box specimens that for some reason had gone wrong after sporoblast and sporocyst formation, respectively. The cyst in fig. 9 might still have been capable of further development, notwithstanding the extrusion of the endoplasmic granules. The occurrence of the clump of granules lying at one side of the center of the cyst measuring about 3.6 μ in diameter, I am inclined to regard as fortuitous and not to be interpreted as an oöcystic residuum.

The cyst shown in Plate 3, fig. 2, was one of the largest I encountered in the study. Unfortunately it was lost before I could measure it. It looked startingly like a developing cyst of *Eimeria*. I had managed to draw the outlines under the camera lucida, when I was called to the telephone. When I returned, evaporation had swept it away and I was unable to find it again.

In only one instance did I find a sporocyst that had become separated from its oöcyst (Plate 3, fig. 12). Dobell quotes Wenyon and O'Connor as reporting the occasional occurrence of oöcysts of *Isospora hominis* containing a single sporocyst with eight sporozoites. I encountered no such forms. Dobell has seen them occasionally in *Isospora bigemina*.

The structure of the fully developed cyst shows considerable variation as regards the shape and size of the oöcysts, the character and amount of sporocystic residuum present, and the arrangement of the sporozoites. I gather from reading Noc's paper, that he is under the impression that the oöcysts increase in size as they reach full development. At the present time I am inclined to doubt if this is really so, but the whole matter of the dimensions of these cysts is a subject I am purposely not taking up in this paper, and I shall defer further consideration of it until I have had the opportunity to go over the measurements I have already made and the measurements of some preserved material. It has occurred to me that there may be races within these species, characterized by the size of their cysts. The difficulty lies in making accurate calculations of the size of cysts that assume such irregular outlines.

It will be seen, by viewing the figures of some of the fully developed cysts (Plate 2, figs. 5 to 11, Plate 3, fig. 10), that the sporocystic residuum shows considerable variation in character and amount. In some cysts (Plate 2, figs. 6, 7, 8, and 10) it is fairly rich and normal-appearing, while in others (Plate 2, figs. 5, 9, and 11) it is formed largely of fine, dark granules and is scant in amount. In others (Plate 3, fig. 10; Plate 2, fig. 12), it appears in the form of dull, hyaline-looking bodies. Both these cysts had been subjected to dessication for one week. These are appearances that are not restricted to this species, but may be seen in other species of coccidia.

DEVELOPMENT OF THE CYSTS AT 10° C

A study of the development of the cysts at a constant temperature of 10° C. was rather interesting. One of the stools studied thus was that of March 21, a portion of which was placed in the ice box a few minutes after it was passed. Twenty-four hours later a sample was taken from the ice box, but none of the cysts had passed beyond the early zygote stage. On the morning of March 23, numerous, well-advanced sporoblasts were seen, also some zygotes, apparently in good condition. There were very few degenerating cysts. Oöcysts containing sporocysts were found on the morning of March 24. The sample taken from the ice box on that day was laid aside on the laboratory table overnight (temperature, 30° to 32° C.). When it was examined the next morning (temperature,

31.5° C.), several cysts containing fully developed sporozoites were found (Plate 2, fig. 8).

Examination of the ice-box material every day until April 3 yielded no cysts beyond the sporocyst stage, while many in the late zygote and sporoblast stages were found each day. Each specimen was left on the table overnight and, each morning after, fully developed cysts were found. On the morning of April 3, just two weeks after the experiment was started, fully developed cysts (containing sporozoites) were found in the fæces immediately after it was removed from the ice box.

In other words, the lowered temperature, as was to be expected, retarded the development of the cysts considerably, but they "picked up" rapidly on being carried into a warmer atmosphere and, after the third day, were capable of completing their development overnight in the higher temperature. The cold also undoubtedly favors the cysts in that it retards the fermentative changes in the fæces that are inimical to the cysts. This would seem to indicate that the temperature in the fall and spring months, and possibly into the early and late winter in temperate climates, will tend to favor the dissemination of the infection. It is not by any means certain that the meteorology of the Tropics will afford favorable conditions for the spread of coccidial infections.

EFFECTS OF TROPICAL SUN ON THE CYSTS

The resistance of coccidial cysts to dessication and the action of chemicals is well known, but it occurred to me that it would be interesting to try the effects of the tropical sun on them. For that purpose the following rather crude experiment was undertaken:

The material used was part of the stool passed on March 16, which had been in the ice box forty-eight hours. At the time the experiment was started, none of the cysts had passed beyond the sporoblast stage. A quantity of fæces was emulsified in physiological salt solution and spread out in a very thin layer on the middle of each of a number of slides. The area covered was square and about equal to the area of an ordinary square cover slip. The slides were quickly examined under the microscope to make certain that they contained cysts and were then placed at the window in the direct rays of the forenoon sun, which is very hot in Manila at this time of the year. The slides were allowed to remain there for about two hours, at the end of which time they were distinctly hot,

and the material on them was literally baked "bone dry." They were then placed in Petri dishes for protection and allowed to remain in the same position, still exposed to the morning sun. This was on March 18.

The slides remained thus exposed to the hot sun for about three hours each forenoon, until March 25. On that day, another set of Petri dishes was prepared with wet filter paper in the bottom of each, forming a set of moist chambers. The dried slides were transferred to these, being supported on match sticks and inverted so the water of condensation from the filter paper would collect on the fæcal film. One or two of the slides were mounted in water and examined under the microscope. Many badly wrinkled oöcysts were found, but the contents had a healthy, greenish tint. All were in early stages of development.

On the following day (March 26) the slides were examined in water mounts, but no changes were noted. On March 27 one fully developed cyst (Plate 3, fig. 10), not visibly deformed, and bearing every evidence of good health save for the unusual character of the sporocystic residuum, was found. This cyst was firmly embedded at one edge in a mass of fæcal débris, but it could be clearly studied. Many cysts found were dead and degenerated, but many zygote, sporoblast, and sporocyst stages, with badly wrinkled oöcysts but with apparently healthy interiors, were also found.

The last examination of the slides was made on the afternoon of March 29. It was found that there was a tendency for the wrinkled oöcysts to smooth out. Some of the fully developed cysts that appeared to be in good condition, showed a close contraction of the oöcyst around the sporocysts (Plate 2, fig. 12). The similarity in appearance of the sporocystic residuum to that of the cyst just mentioned should be noted. Numbers of apparently healthy cysts in intermediate stages of development also were found, as well as many, before observed, that clearly were dead.

The experiment, rough as it was, showed that complete dessication of the fæces and daily exposure for at least three hours to the tropical sun over a period of a week will not prevent the full development of at least a portion of the cysts in a stool, as soon as a condition of moisture is restored. How long it would take the cysts to develop without the subsequent interposition of moisture, I cannot say, but I believe they would develop in the course of time.

Of course, infection experiments, only, would prove that the fully developed cysts I observed were actually living and capable of infecting a new host; but the sporozoites bore every evidence from their color and general appearance of being alive.

A series of experiments designed to establish the resistance of the cysts to various chemical agents was also undertaken, but the results so far secured are not altogether satisfactory. For that reason a report on them will be deferred to a later paper. I am inclined to suspect, however, that the cysts of *Isospora hominis* are not so resistant as those of *I. bigemina*.

EPIDEMIOLOGICAL CONSIDERATIONS

The epidemiology of human coccidiosis offers the subject of a rather interesting study. It is a study, however, that is fraught with not a little difficulty to the microscopist who is unfamiliar with the sporozoa. It is true that the present geographical distribution of the coccidia of man rather closely coincides with the geographical distribution of experienced protozoölogists, but there is the not less-striking fact that a large proportion of the cases so far reported can be more or less directly traced to one source—the eastern Mediterranean area, Mesopotamia, or the Balkans. In fact, out of the cases shown on the map accompanying this paper only four, Noc's Saigon case (the identity of the parasite here is not established), the two cases found by Miss Porter in Johannesburg, and Snijders' Sumatra case, appear to be untraceable. Moreover, while there have been changes in personnel in the different laboratories where large numbers of stools are examined, protozoölogists have been pretty well scattered about the world for years. War conditions will account for the discoveries of the early cases, but they do not account for the later detections.

Dobell(3) has thoroughly reviewed the situation up to 1919, so it is unnecessary to repeat the statistics he has given and the illuminating comment he has made. The principal findings are plotted on the map. Dobell(5) also has disposed of two fictitious cases of human coccidiosis, so they need not be considered here.[1] For the purpose of tracing the case reported in this paper, however, it is necessary to recall that Brumpt has stated that the French armies were infected with *Eimeria* to the extent of 0.2 to 0.33 per cent. Nothing, however, is said about *Isospora*

[1] I refer to the cases reported by Huetter and by Lockhart Mummery and Gabriel.

infections; but I think we may safely assume that, if the French troops were infected with *Eimeria*, they were infected with *Isospora* as well, especially as *Isospora* infections so far reported seem to outnumber the *Eimeria* infections.

Porter,(13) in 1917, discovered two cases of infection with "*Isospora bigemina* var. *hominis*" in Johannesburg. One of these infections was in a Hottentot, and the other in a Dutch South African who had never been out of the country. No data are given that will aid in tracing these cases. Noc,(12) meanwhile, in 1916, had picked up a case of *Isospora* infection in a European at Saigon. The case was lost to study after the first examination of the fæces, and Noc has ventured the supposition that the man had been eating rabbits' livers that were infected with *Isospora bigemina*. As he gives no description of the cysts he found, it is impossible to pass judgment on this. No information was obtained as to the previous travels of the man.

Noc, fortunately, was able to secure more detailed information concerning the travels of the man whose case he recently reported from Senegal.(12) His description leaves no room for doubt that the infection was with *Isospora hominis*. The man had been at St. Mihiel, and had been a prisoner of war in German camps in Westphalia, Wurtemburg, and Hanover, where the sanitary conditions were very bad. The patient had every opportunity to pick up his infection at any of these four places, and it seems to be perfectly reasonable to assume that the ultimate source of the infection was the eastern Mediterranean area.

Snijders(14) reported his case almost coincidentally with Noc, while Dobell(5) has confirmed his findings and has given the name *Eimeria snijdersi* to the parasite, thus bringing the total number of species of coccidia known to be parasitic in man up to five.[2]

Snijders' case was presented by a man at Medan on the east coast of Sumatra, who had lived in the Tropics for ten years. He gave a history of amœbic dysentery extending back for five years. The infection seems to have been especially intractable, for it had failed to yield either to emetine or to emetine bismu-

[2] For the present, at least, I think we must accept Dobell's judgment regarding Gubler's coccidium of the human liver. Dobell has left the naming of this organism to some investigator who, in the future, may run across and study it. He merely designates it as "an undetermined species of *Eimeria* (*?*)."

thous iodide. The cysts of this coccidium appeared only once in the stools of the patient, but on that occasion they were exceedingly numerous. Snijders has given a good description of them; and Dobell,(5) who studied some of his material, has shown that the species is entirely distinct from *Eimeria oxyspora,* to which it bears a superficial resemblance in that it forms whetstone-shaped spores. There the resemblance ceases.

This case, of course, must be looked upon as an isolated one. The parasite bears no real resemblance, beyond its generic characters, to any of the other Eimeridæ that have been reported as occurring in man, and there is nothing in the history of the man's travels that would lead us to believe that he contracted the infection outside of Sumatra. Snijders observed no intestinal symptoms that could be attributed to the coccidia.

One more report requires special reference at this time, because it carries the infection farther east and helps to establish the banding of the globe by *Isospora hominis.* That is the report of Cragg,(1) who in 1918 recorded four cases of *Isospora* infection in men returned from Mesopotamia. Reference to these cases will be made later.

If we are to regard the five species of coccidia [3] now credited with being parasitic in man as specific parasites of man, and evidence to the contrary is lacking, we must expect to find many more infections; for every one of the cases reported must, of course, have been derived from an infection in some other man. It is rather trite to say that these strains must have been carried on for long periods of time, and there is little reason to believe that they are about to perish abruptly at this time.

It is barely possible that the dissemination of human coccidial infections is partially governed by environmental conditions of a peculiar nature, but the distribution already has reached points in the Tropics as well as in temperate regions. However, very little has been learned as to how much dissemination occurs at any points outside of the eastern Mediterranean area. Dobell,(6) in his recent report on autochthonous infections with intestinal protozoa among inhabitants of Britain, says:

> I would particularly emphasize the fact that no infections with intestinal coccidia or with *Balantidium* appear to have been reported in British residents who have never been abroad. As regards the former, it may be noted that there is one British case of supposed coccidiosis of the liver (Silcock, 1890); but this is still somewhat doubtful.

[3] I refer to *Eimeria wenyoni, E. oxyspora, E. snijdersi, E.* (*?*) *sp.* and *Isospora hominis.*

This would seem to me not to be particularly surprising, if we regard the invasion of Britain by the coccidia of man as having taken place under war conditions and during that period. The only way in which it seems to me possible to establish if conditions in Britain are favorable to the dissemination of coccidial infections in man would be to trace the cases among returned soldiers that have been observed and round up their contacts both before and after their infections were discovered. To be sure, this might be difficult. It would seem to me to be a highly desirable and rather interesting thing to do this at all points where *Eimeria* and *Isospora* have been reported.

The reports of Kofoid and his coworkers indicate strongly that coccidial infections have reached the United States from the eastern Mediterranean country, probably by way of France; and there is reason to believe that dissemination has taken place, as witness the four autochthonous infections reported by him. Of course, there remains the possibility that the infection has been mildly endemic in the United States for a long time, and unless we can get detailed data regarding the antecedents of the four cases he reports in home-service troops, which would dispose of that idea, we must continue to carry it in mind.

Kofoid's findings were made in the course of the study of the stools of between 2,000 and 3,000 overseas and home-service troops at Debarkation Hospital No. 3, New York, in 1919. In his first paper(10) Kofoid states that the overseas troops had seen service in Flanders, Chateau Thierry, the Argonne, and Toal, while some of them had been in France but had never seen service at the front. These troops served in 584 regiments and had been recruited from every state in the Union. Only a small proportion of them had served on the Mexican border. The home-service contingent was largely composed of cooks, bakers, and food handlers from the point of debarkation—principally from the medical department. The names of 27 per cent of these were suggestive of Russian, Polish, Italian, or Spanish nationality. Seven of them were negroes from Florida. In his first paper, Kofoid records the findings in his table, making no allusion to them in the text. He found and recorded, under the name *Isospora,* six infections in overseas troops and four in home-service troops.

In the second paper,(11) which apparently represents a continuation of the previous work, and which is reported more fully in the transactions of the American Gastro-enterological Asso-

ciation for 1919,[4] seven cases in overseas and four in home-service troops are recorded in the accompanying table under the term Sporozoa. I am assuming that the second paper represents an extension of the work reported in the first and therefore have considered that Kofoid and his coworkers found eleven cases in all, four of which are under suspicion as being autochthonous.

I think we may safely assume that the case reported by me was autochthonous in the United Sates, because there was small chance of its having been picked up in Japan en route to the Philippines, and I doubt exceedingly the presence of human coccidial infections in the Philippine Islands prior to this case. In the United States there is a very suggestive history of contact at the munitions works in Nitro, although the method by which infection might have been brought about is not so clear. At the front the conditions for the dissemination of intestinal parasites were rather favorable, and that, coupled with the thorough system of stool examinations carried out by the allied armies, explains the comparatively large number of cases that were discovered during the course of the war.

Taking all these things into consideration and adding the interest in and knowledge concerning these parasites that is certain to follow recent work on them, I think we may expect to hear of other cases in the United States as well as elsewhere.

Turning back to the Manila case, we find a state of affairs that is not without promise of future developments. When this patient stopped at Cotabato in the course of his trip, he lived at the local hotel. The sanitation there he reports as very bad, the water closet being located next to the kitchen. At Parang and Reina Regente, which he also visited, the sanitary conditions were somewhat better. The method of disposal of excreta at these places is what is known as the "can system." By this method, the fæces are passed into large gasolene cans to await the convenience of the attendant delegated to look after them. In well-regulated households the cans are kept covered and are emptied rather frequently, and thus secured against invasion by flies, cockroaches, and other itinerant scavengers; but not all households are well regulated, so that the system sometimes breaks down and becomes a serious factor in the dissemination of intestinal infections. The methods of disposing of the contents of the cans is not always what it should be.

[4] I have not, so far, seen this paper.

It was in the Bual district, however, where the excreta disposal conditions were the worst. In this section of country, where there are any closet facilities whatever, the system is what is colloquially spoken of as the "pig system." The "pig system" is widely employed throughout the Tropics as a labor-saving institution under the mistaken notion that the pig altruistically protects mankind against the spread of intestinal diseases. Incidentally, his activities are supposed to result in economy of municipal funds. I have accumulated sufficient evidence during my stay in the Philippine Islands to convince myself that in his rôle as a sanitarian and public benefactor the domestic pig is a dismal failure, and that, while he brings about a superficial appearance of cleanliness, he really makes a bad matter worse by distributing a more or less localized filth broadcast within a settlement. The back doors of latrines are left open for his convenience, he avails himself of the facilities thus afforded him, and then sallies forth upon the highway and among the children of the village, in their mud-pie industry, fulfilling his errand of dissemination. In the course of time he has distributed his consignment of human parasites, shipped at the latrine, and may even have added a few of his own in the form of *Balantidium coli.*

From such observations as I have been able to make, I believe that the ova and cysts of the general run of intestinal parasites of man pass unchanged through the alimentary tract of the pig and emerge quite as potential for harm as if they never had made the journey. Therefore, it seems to me not at all unlikely that in this country, where the parasitic index already is high, we may expect, in the course of time, to encounter new cases of infection with *Isospora.*

There are several means by which the cysts of *Isospora* in an infective stage may be transmitted in a country such as this. Direct transmission through the medium of the soiled hands of a food handler is not altogether impossible for I have shown (p. 462) that, under certain conditions, cysts may reach full development within thirty-two hours after the passage of the stool containing them. I have known food handlers who refrained from washing their hands over even longer periods than this. Flies, pigs, and probably cockroaches must be accepted as likely vectors, and there is the old bogey of green vegetables fertilized with human excreta. In fact, the methods of transmission are much the same as in the case of the other intestinal Protozoa. Peculiar factors involved are the longevity and

higher resistance of the cysts and the fact that a longer period of exogenous development is required before the cysts of *Isospora* become infective. With *Eimeria* this period is greatly reduced, for the cysts of species of this genus may be passed almost fully if not completely developed. Other protozoan cysts are usually fully developed when they leave the intestine and are more vulnerable to unfavorable environmental conditions.

The self-limiting nature of intestinal coccidiosis precludes the occurrence of coccidia carriers. This, of course, presupposes the avoidance of reinfections of the original host, that may operate to bring about the more or less constant discharge of cysts over periods beyond the duration of a primary infection.

It will be a matter of interest, moreover, to watch the developments in the United States, for it is my belief that other cases will occur there and add to the new problems that the home-coming soldier has brought with him. In this connection I am minded to repeat certain remarks I made in the course of a paper published in 1917:(8)

> The importance of the protozoa as the causative factors in many grave diseases is thoroughly recognized today by every alert practitioner, particularly those whose labors carry them into tropical or semitropical zones. There is likewise a gradual awakening to the fact that many parasitic protozoa do not restrict their activities to those localities, but, on the contrary, are exceedingly ubiquitous. With the opening up of new trade routes and the broadening and development of commerce to the Far East, South America and Africa, and as a result of conditions which are developing with the progress of the European war, they are gradually establishing themselves in cooler climes. The malarial parasite has long been known too well in North America, and there is a growing realization that endamebic dysentery is not by any means a rare malady in the same territory. The medical schools of the United States will have to cope with this situation before long, and they can meet it only by extending their curriculums so as to meet the protozoölogical needs, not only of the men who will have to deal with conditions at home, but also of the rapidly increasing number of medical men who are answering the call to the tropics.

PATHOGENICITY

Before going into the question of pathogenicity and the problem of the treatment of coccidial infections in man, it may be well, for the benefit of those who have not had the opportunity to study these organisms, briefly to review the coccidial life cycle. In all essential points, the life cycles of species of the genera *Eimeria* and *Isospora* coincide with that worked out by Schaudinn for *Eimeria* (*Coccidium*) *schubergi*, parasitic in the gut of *Lithobius forficatus*. The parasite enters the alimentary tract of the host in encysted form. In *Eimeria* these cysts (oöcysts), on full development, contain four dizoic spores;

in *Isospora* there are two tetrazoic spores, there being eight sporozoites formed in each case. In the intestine the vermiform sporozoites emerge from their containing cysts and invade the epithelial cells of the mucosa of the small intestine. In some instances the epithelium of the bile ducts is invaded, but this seems not to be the case with species of *Isospora,* which seem to restrict their activities to the intestine. They are obligatory epithelial-cell parasites. Within the host cell the sporozoites develop into trophozoites, which grow at the expense of the protoplasm of the host cell. When the food supply has become exhausted, and the trophozoite has attained full growth, the nucleus undergoes multiple division (schizogony) and with plastogamy a number of daughter cells, or merozoites, are formed.[5] These escape from the host cell and enter the bowel lumen to seek new host cells. Those that are successful, in their turn develop into trophozoites which also undergo schizogony. This asexual cycle is repeated a variable number of times, depending upon the vitality of the race,[6] and finally changes take place leading to a sexual process (sporogony), which is initiated by a process of fertilization involving the union of sexually differentiated gametes. This is followed by the encystation of the zygote, which then passes out of the fæces and completes its development in the outer world. It so comes to pass that in the course of events the entire race, in time, undergoes sporogony and the host becomes purged of his infection. In this respect, the infection may be said to be self-limited, and if the host can withstand the initial onslaught, his chances for recovery are good. No immunity is conferred, however. In a large proportion of cases the host seems to undergo no marked discomfort, while in others, as in the case of the karyozoic parasite *Cyclospora caryolytica* of the ground mole, the symptoms may be very acute and rapidly progress to a fatal termination. In other cases, the infection may drag along for a long period of time, the host constantly discharging cysts. In such cases, however, it is necessary to rule out reinfection with a new crop of parasites.

[5] Porter says fifteen to twenty merozoites are produced from one schizont in the *Isospora* of man. I presume she bases this statement on the infection experiments of Fantham with kittens, the report of which I regret to say I have not seen.

[6] Some authors maintain that "virulent" infections leading to extensive destruction of tissue bring about a condition which stimulates the development of sporogony and thereby relieves the situation.

There is some diversity of opinion regarding the pathogenicity of *Isospora hominis*. Fantham,(7) in a paper which I regret is not accessible to me, has claimed success in infecting kittens with *Isospora hominis*, and to have produced a condition in the intestines "resembling that seen in the human intestine examined post mortem." In a footnote (p. 186) Dobell(3) comments: "This, however, has never been described, so far as I am aware; and the statement can hardly be accepted without some concrete evidence to support it."

Animal experiments, with this exception, that have so far been attempted with this parasite have uniformly failed, attempts having been made with kittens, a mouse, and two young puppies. Noc(12) also fed the cysts to a white rat, but up to the time he wrote his paper he had secured no evidence that infection had taken place.

Practically all writers agree that the parasite has a certain potentiality for harm, but one great objection to many of the observations made lies in the fact that the patients were suffering from dysentery or some other intestinal ailment that would tend to obscure any existing coccidial symptoms. In one case studied by Wenyon(17) in which there were a concomitant infection with *Entamoeba coli* and dysenteric symptoms, no cause for the dysentery could be found and Wenyon remarks that "It may have been that the dysenteric symptoms of this case were due to the coccidium, for no pathogenic bacteria had been isolated from the fæces;" which, however, does not necessarily follow, as one may gather from the conservatism of the statement. Dobell(2) states his conclusions (p. 68) as follows:

> No evidence is brought forward to show that either of the Coccidia found (*Isospora* or *Eimeria*) is pathogenic. As both of these are tissue-parasites, which probably invade the cells of the small intestine, it is possible that they may give rise to pathological conditions. At present there is no indication that this is so. It may be added that many animals appear to suffer no inconvenience from immense infection with coccidia; and it is quite possible therefore that the forms occurring in man are of no practical importance.

The watery diarrhœa reported in three of Cragg's Mesopotamia-Bombay cases looks interesting, but the cases are too clouded by dysenteric complications to admit of much stress being laid upon them. It is greatly to be regretted that the opportunity afforded for a study of the intracellular stages of

the parasites in Cragg's two cases that went to autopsy was not realized.

I am strongly of the belief that the symptoms exhibited by my patient were due to his coccidiosis. Beyond an infection with Blastocystis he carried no parasites except the *Isospora*, and much of the time his diet was under strict regulation. Noc's patient complained of pain in the right iliac region, and he exhibited hepatic enlargement and persistent diarrhœa. Noc reports the presence of no other intestinal parasite, although the high eosinophile count (6.5 per cent) looks suspicious.

The gross and microscopical lesions accompanying infections with *Isospora hominis* must remain a matter for speculation until some case goes to auptopsy. Porter(13) says the epithelium of the ileum is often most heavily infected and that the jejunum is also invaded. This postpones the settlement of the whole question of pathogenicity. Cases so far reported have been in adults and the symptoms—when there have been any—seem not to have been grave. We have yet to see how it will affect young children and enfeebled persons. The best account of the microscopical lesions accompanying coccidiosis that is available to me is that of Tyzzer,(15) who studied coccidiosis in the bile ducts of the rabbit. He says (pp. 249 to 251):

> The parasites attack only epithelial cells. The young form inhabits the protopasm of the cell, which becomes more and more distended as the parasite develops. The nucleus, at first slightly indented, later becomes crescent-shaped. The structure of the chromatin cannot be made out, and the nucleus is stained darkly. Thus at the termination of this process, the epithelial cell is reduced to a sac containing a parasite, having on one side a darkly stained crescent, representing the degenerated nucleus * * *. Ruptured cells are found from which the parasites have been set free. Degeneration and destruction of epithelial cells thus follow their invasion by parasites. Numerous mitoses are seen in the epithelium and, where the infection is not overwhelming, proliferation is in evidence. The epithelium is markedly thickened and its cells are crowded. Accompanying the destruction of single cells, exudative phenomena are absent. With the destruction of small areas of epithelium, there is exudation of fibrin and leucocytes * * *. The latter occurs, however, only occasionally, and is the exception rather than the rule. When bacteria are present, the exudative phenomena are increased. The surrounding connective tissue is rich in cells. There are large numbers of lymphoid and plasma cells. Epithelioid and lymphoid cells occur between the cells of the epithelium. The epithelium oftentimes lacks a definite basement membrane, and young connective tissue and epithelium is so mingled that the resulting relations are

decidedly confusing. Large phagocytic giant cells occur in conjunction with collections of oöcysts, the latter acting as foreign bodies. In some lesions large numbers of eosinophile cells are found scattered through the connective tissue.

The formation of the papilliform projections is to be explained by the hyperplasia of the connective tissue, which pushes through the defects in the epithelial layer. The question arises as to whether the proliferation is primarily of the epithelium or of the connective tissue. As proliferation is never confined solely either to epithelium or to connective tissue, it is to be presumed that the process involves both tissues at the same time. The steps of the process may be summarized as follows:

Following the invasion of its protoplasm by a parasite, the epithelial cell undergoes gradual but inevitable degeneration and finally becomes destroyed. The death of the cell produces a defect in the epithelial lining of the bile-duct. With the destruction of several adjacent cells the injury is greater and exudation of fibrin and leucocytes may take place. On account of the defect in the ephithelium, the underlying connective tissue is stimulated and proliferates. Pushing through the break in the epithelial layer, it forms the papilliform projections before described. At the same time the epithelium proliferates in an attempt to repair the defect in its continuity. As the parasites multiply, many mature forms become free in the bile-ducts, where they cause irritation, acting as foreign bodies.[7]

Evidence of this irritation is seen in the thickening and hyperplasia of the epithelium of the small ducts and in the hyperplasia of the surrounding connective tissue. In some instances the biliary epithelium is desquamated and portions of it are passed down the ducts. The epithelial cells often present a peculiar change in their nuclei * * *. The chromatin is condensed into several intensely staining masses which lie against the nuclear membrane. The nuclear material apart from the chromatin is unstained. The nucleus as a whole is abnormally large and appears hollow. Councilman has described similar changes in the corneal corpuscles of the rabbit's cornea. In that instance this arrangement of the chromatin preceded the direct division of the cell and was regarded as a degenerative change.

It seems to me that the contingency mentioned in Tyzzer's footnote is one that may have to be reckoned with in heavy intestinal infections. Both my case and that of Noc showed that many epithelial cells are cast off during the progress of the infection. Tyzzer summarizes, in part, as follows:

The lesion is of the nature of a chronic inflammatory process. The tissues react to the irritation which the parasites cause by their presence in the bile ducts. With the removal of the irritation, repair takes place. Thus the whole is to be regarded as a physiological process, checking the inroads

[7] There is no evidence that the parasites of themselves secrete any toxic substance, but their presence in the biliary epithelium renders it more liable to bacterial invasion. In some instances the effect of bacteria is to produce an abscess cavity, in which but few coccidia are to be found. (This footnote is Tyzzer's.—F. G. H.)

of the parasite. * * * The process is self-limited and repair follows the destruction of the parasites.

I have noted, in connection with the study of some coccidia found in the little wall lizards that are common about Manila, that infections seem at times to progress rather far, distally, along the intestine. This is something I believe other workers have noted in the past. It is quite conceivable that a vigorous race of coccidia might make a rather long journey along the intestine before sporogony intervened, and it is possible that effects may be seen in the functioning power of the mucosa long after the infection has actually gone.

TREATMENT

Treatment for intestinal coccidiosis remains to be worked out. In fact, it may be maintained that, in as much as these coccidial infections tend toward self-limitation, the matter is of little moment. Before adopting that stand as a matter of policy it would seem to me to be wise to follow some of the old cases and see how they are faring, to give close clinical study to such new cases as may be detected and, moreover, to make a careful study of any cases that may occur in children and in people of enfeebled constitution.

So far, emetine has failed absolutely, and nothing conclusive is shown by Noc's case(12) that he treated with novarsenobenzol and thymol. Miss Porter,(13) in speaking of one of her Johnnesburg cases says (p. 27): "After the elimination of the parasite by appropriate treatment the man recovered." This patient was at first thought to be suffering from amœbic dysentery, but *Isospora* was the only protozoan parasite found and Miss Porter says (p. 19): "* * * with its destruction and elimination the symptoms also disappeared." Unfortunately, the writer gives no information as to the nature of the treatment that was instituted in this case.

Attempts at treatment of these coccidial infections are likely to meet the same obstacles that are encountered with *Giardia* infections. It is barely possible that the intracellular forms may be reached with some arsenical preparation. Merozoites entering the lumen of the bowel might be reached by a drug such as thymol or oil of chenopodium, but the drug would have to be exhibited at a time when merozoites were being discharged and it might not reach those deep in the intestinal crypts. On

theoretical grounds, it would seem appropriate to outline the campaign against the parasites much as is done in malaria, and deliver the drug to the bowel lumen at about the time that schizogony is taking place, for the merozoites would appear to be the most vulnerable forms in the life cycle.

The difficulty here lies in the determination of the time at which schizogony takes place through some physical sign exhibited by the patient. It would also be useful to know if schizogony in these coccidia is synchronous and rhythmic as it is in *Plasmodium*. It is reasonable to expect that such is the case, for the mature spores ingested by the host are all fixed at one stage in the life cycle, and those entering the small intestine might be expected to open rather promptly so that the sporozoites would begin their development in the epithelial cells at approximately the same time.

During the progress of my case I tried, so far as possible, to discover some sign that would tend to fix the time at which schizogony was taking place, but I failed. In questioning the patient about the character of the stools he passed each day I was told by him that he had noted some periodicity in the diarrhœa. That is to say, on one day the stool would be normal, on the next day it would be soft or watery, the following day normal, and so on. In other words he was inclined to believe that the periodicity was tertian. As I had asked rather leading questions, I tried not to place too much stress on the periodicity, especially as it seemed to lead very little nearer to what I was seeking. However, I note that Noc,(12) in speaking of diarrhœa in his patient, says (p. 786):

> La diarrhée actuelle a débuté vers la fin d'août, 3 ou 4 selles par jour, liquides fétides, noirâtres, survenant surtout le matin. *Courtes rémissions de 24 heures.*[8]

This is offered merely as a suggestion for later work and not because I believe that it is particularly definite. It may be that the simultaneous penetration of a large number of merozoites into epithelial cells at approximately the same time causes sufficient irritation of the intestine to set up a diarrhœa. That being the case, it would only remain to determine the time, making suitable allowance for the appearance of the diarrhœa and then administer a drug (yet to be determined) at a time when it would find the merozoites seeking new host cells. This

[8] The italics are mine.—F. G. H.

would seem to me to establish a scientific basis for treatment, if the facts could be determined.

ACKNOWLEDGMENT

I would, indeed, be ungrateful were I to close this paper without a word of thanks to this patient who faithfully and patiently brought me the material that forms the basis of it. Notwithstanding he was feeling really ill much of the time and was pressed with business in the bargain, he visited my laboratory several times for the purpose of furnishing me with fresh material. A worker in another branch of science unrelated to zoölogy, he entered into the spirit of the study with interest and with as much enthusiasm as it is possible for a man to assume when he feels sick and is uncertain as to the outcome of it all. He received no treatment other than the assurance that the infection would, in time, die out. It was very pleasant to tell him on the day of his departure for the United States that his infection was dying out and that he probably soon would be rid of it.

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ILLUSTRATIONS

[Figures drawn by Haughwout from camera lucida sketches. Map drawn by Macario Ligaya.]

PLATE 1

FIGS. 1 to 10. Stages of sporoblast formation in *Isospora hominis* (Rivolta).

PLATE 2

FIG. 1. Late sporoblast stage in *Isospora hominis* (Rivolta).
FIGS. 2 and 3. Sporocyst stages.
FIG. 4. Early development of sporozoites.
FIGS. 5 to 11. Types of cysts in full development.
FIG. 12. Fully developed cyst after one week of dessication.

PLATE 3

FIGS. 1 to 12. Types of degenerated cysts of *Isospora hominis* (Rivolta).

PLATE 4

Map showing geographic distribution of human coccidiosis.

TEXT FIGURE

FIG. 1. Oscillation of sporoblasts following cell division in *Isospora hominis* (Rivolta).

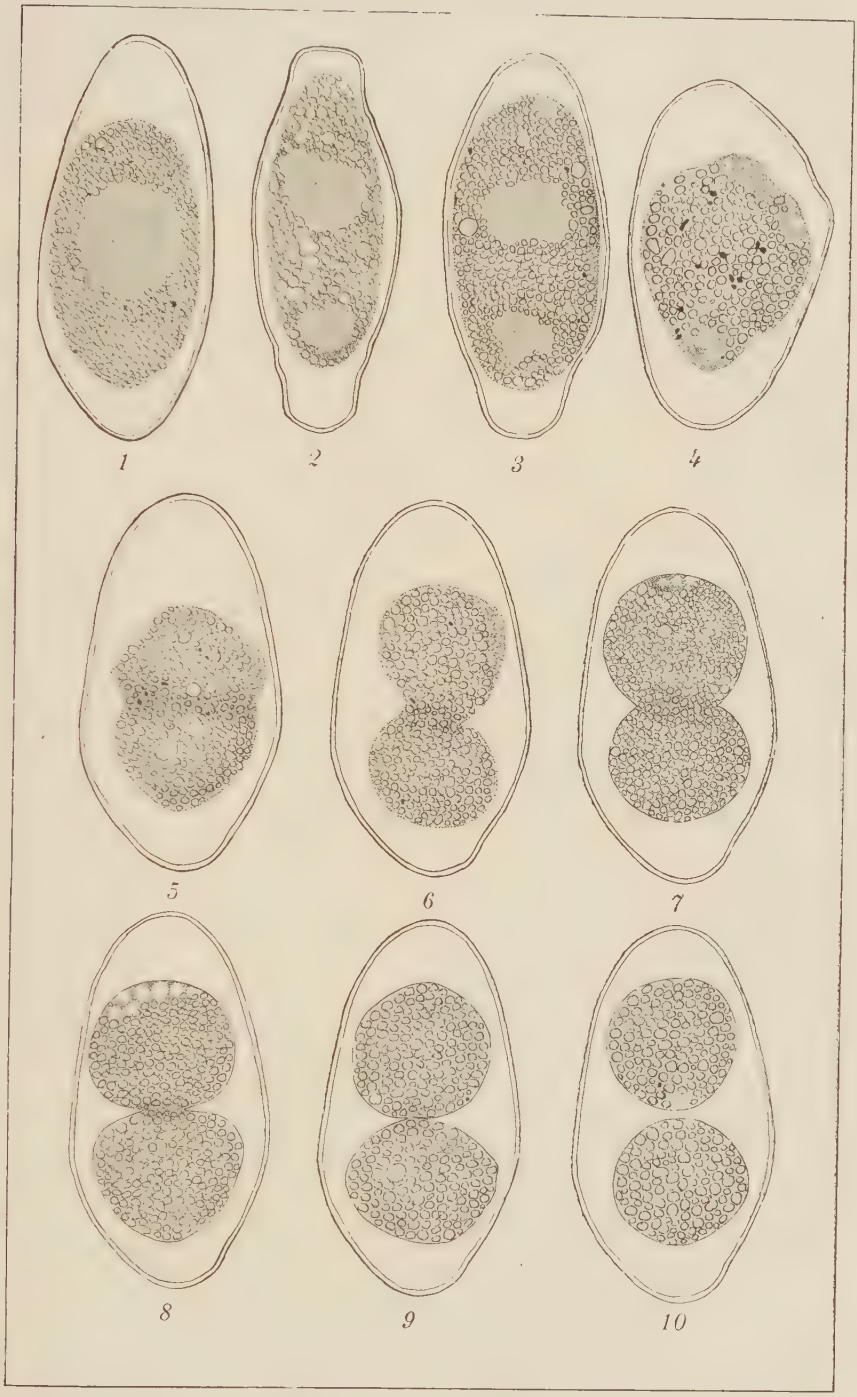

PLATE 1. ISOSPORA HOMINIS (RIVOLTA).

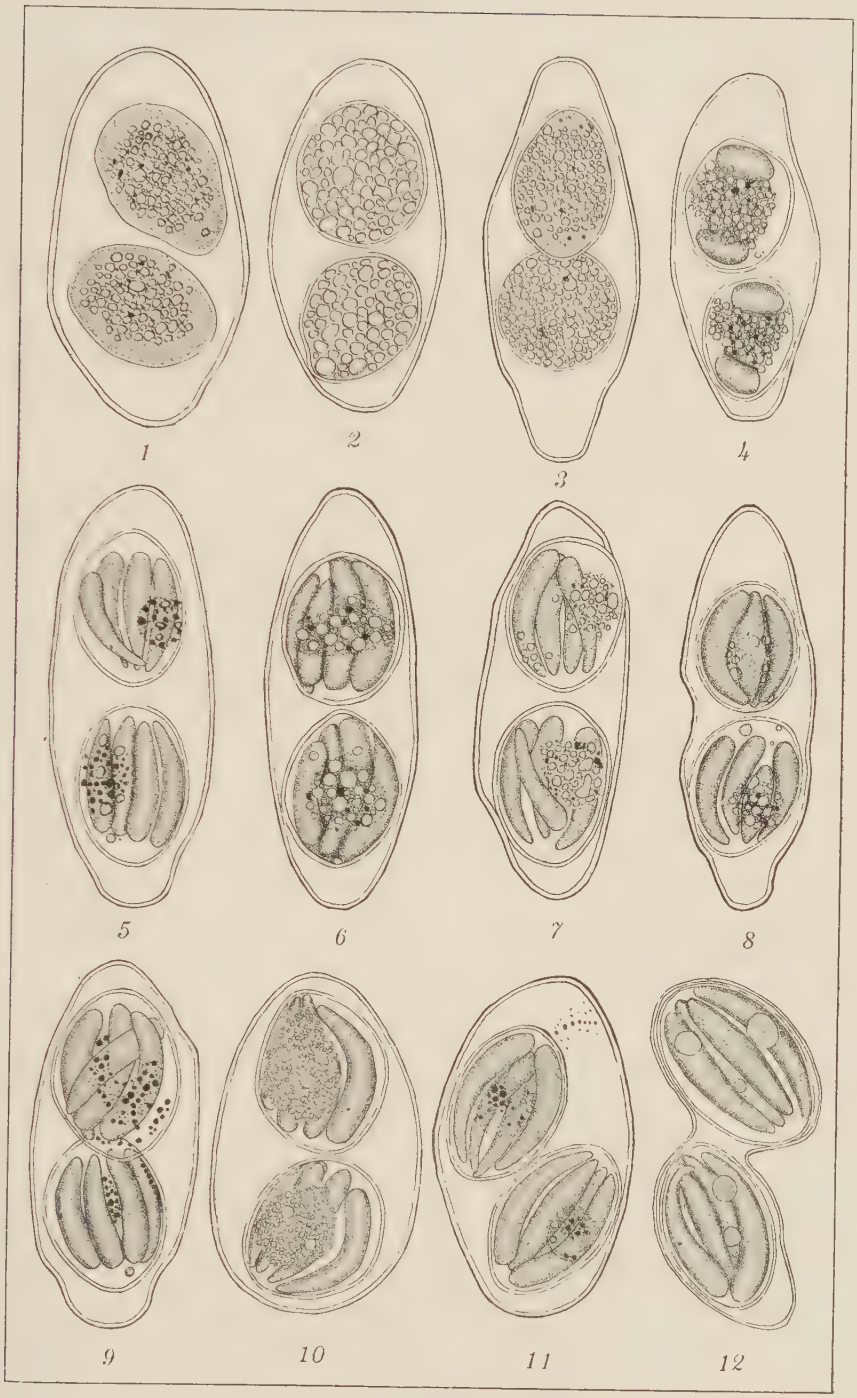

PLATE 2. ISOSPORA HOMINIS (RIVOLTA).

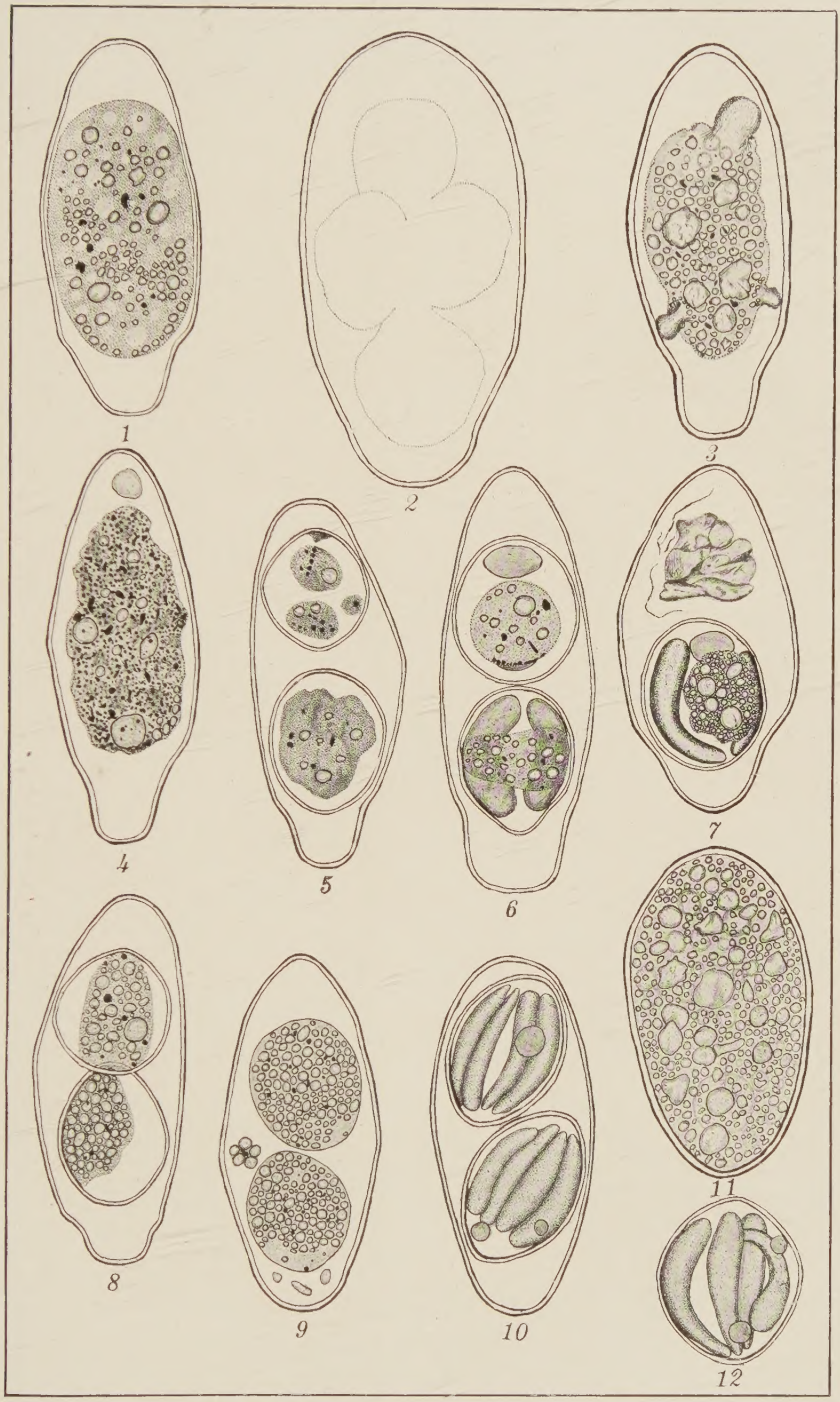

PLATE 3. ISOSPORA HOMINIS (RIVOLTA).

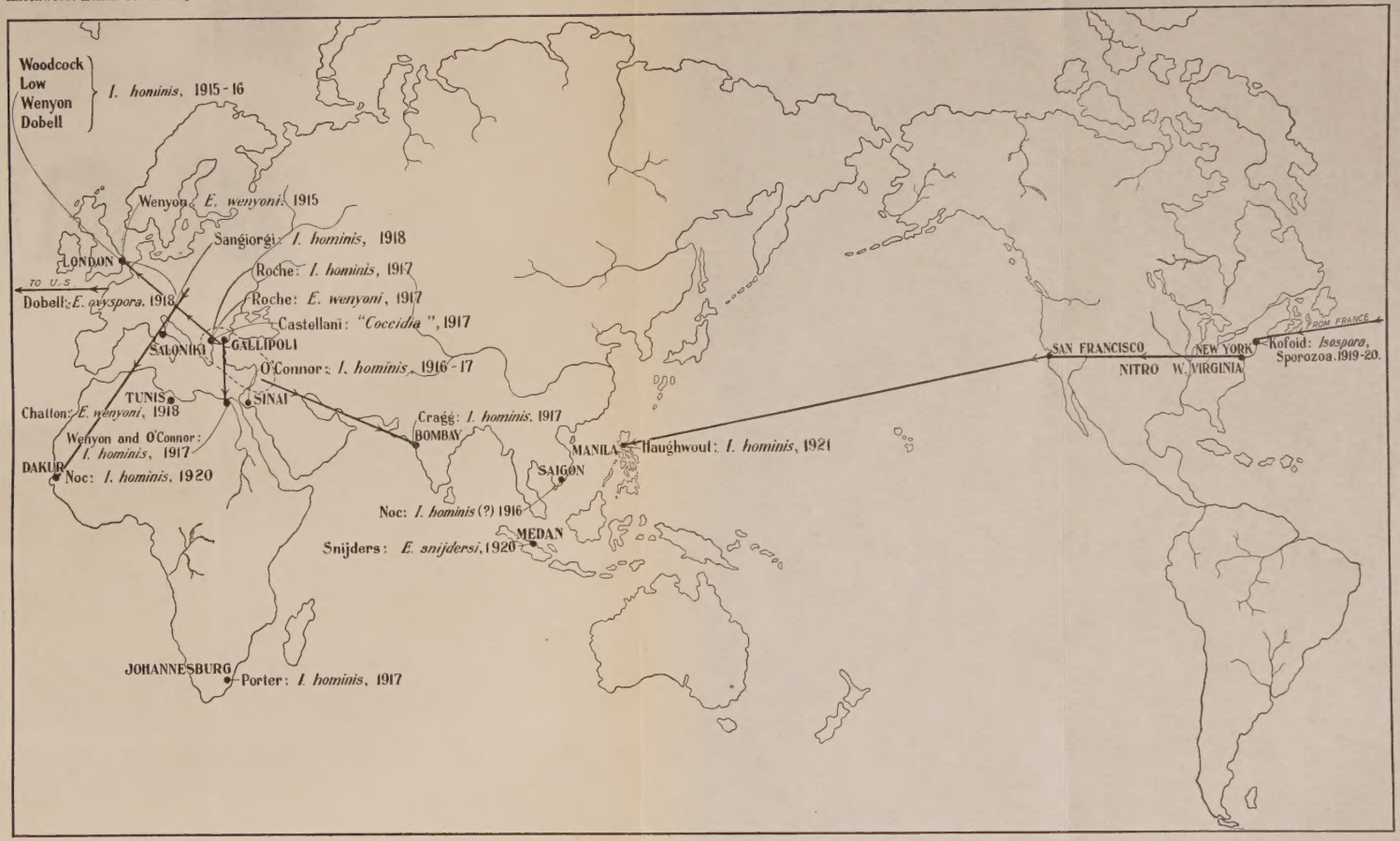

PLATE 4. THE GEOGRAPHIC DISTRIBUTION OF HUMAN COCCIDIOSIS.